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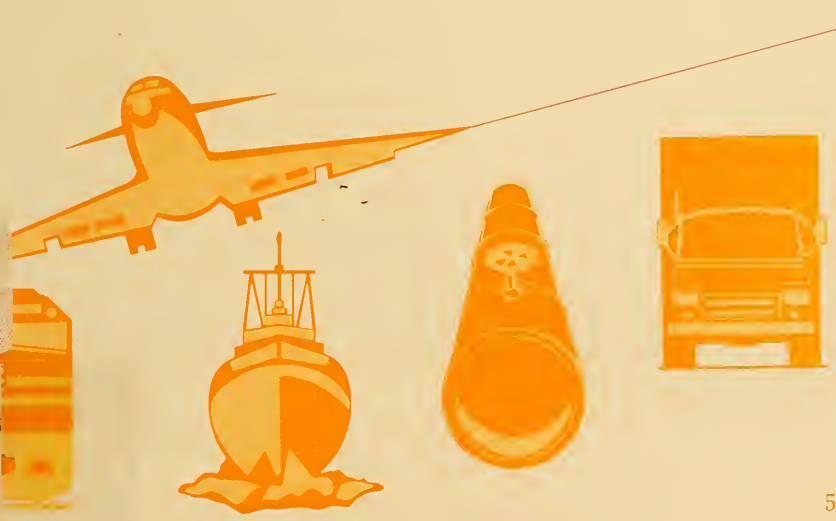
HIGHWAY ACCIDENT REPORT

MULTIPLE VEHICLE COLLISION
AND FIRE IN A WORK ZONE
ON INTERSTATE HIGHWAY 79 NEAR
SUTTON, WEST VIRGINIA
JULY 26, 1990



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The Safety Board makes public its actions and decisions through accident reports, safety studies, special investigation reports, safety recommendations, and statistical reviews. Copies of these documents may be purchased from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161. Details on available publications may be obtained by contacting:

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HIGHWAY ACCIDENT REPORT

MULTIPLE VEHICLE COLLISION AND FIRE IN A WORK ZONE ON INTERSTATE HIGHWAY 79 NEAR SUTTON, WEST VIRGINIA, JULY 26, 1990

ADOPTED: 5/16/91

NOTATION: 5369A

Abstract:

This report explains the multiple vehicle collision and fire in a work zone on Interstate Highway 79 near Sutton, West Virginia, on July 26, 1990. The safety issues discussed in the report are commercial driver fatigue; the adequacy of the oversight exercised by Double B Auto Sales, Inc., to ensure that its truckdrivers obtained adequate rest; the use of available tiedowns by the Double B truckdriver to secure the automobiles being transported on his truck; the adequacy of highway work zone safety features and signing to alert inattentive motorists to the presence of the work zone; and driver licensing and suspension procedures by the State of New York. The National Transportation Safety Board made safety recommendations addressing these issues to Double B Auto Sales, Inc.; the West Virginia Department of Transportation; the State of New York; the National Automobile Transporter's Association; and the Federal Highway Administration.

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EXECUTIVE SUMMARY

About 5:40 p.m. on July 26, 1990, a truck operated by Double B Auto Sales, Inc., transporting eight automobiles entered a highway work zone near Sutton, West Virginia, on northbound Interstate Highway 79 and struck the rear of a utility trailer being towed by a Dodge Aspen. The Aspen then struck the rear of a Plymouth Colt, and the Double B truck and the two automobiles traveled into the closed right lane and collided with three West Virginia Department of Transportation (WVDOT) maintenance vehicles.

Fire ensued, and the eight occupants in the Aspen and the Colt died. The Aspen, Colt, Double B truck, and two of the three WVDOT vehicles were either destroyed or severely damaged. The Double B truckdriver and one firefighter sustained minor injuries.

The National Transportation Safety Board determines that the probable cause of this accident was the inattention of the driver of the Double B Auto Sales, Inc., truck due to fatigue, exacerbated by an inadequate and unbalanced diet the day of the accident, and the inadequacy of the oversight exercised by Double B Auto Sales, Inc., to ensure that its drivers were qualified and received adequate rest. Contributing to the cause of the accident was the less than optimal work zone control devices and procedures used by the West Virginia Department of Transportation. Contributing to the severity of the accident was the operation of the Double B vehicle at a speed in excess of the posted limit, creating a speed differential between the Double B truck and the other involved vehicles, and the Double B truckdriver's failure to properly secure the automobile being transported on his vehicle's head ramp.

The safety issues discussed in this report include:

- commercial driver fatigue;
- the adequacy of the oversight exercised by Double B Auto Sales, Inc., to ensure that its truckdrivers obtained adequate rest;
- the use of available tiedowns by the Double B truckdriver to secure the automobiles being transported on his truck;
- the adequacy of highway work zone safety features and signing to alert inattentive motorists to the presence of the work zone; and
- driver licensing and suspension procedures by the State of New York.

As a result of its investigation, the Safety Board issued safety recommendations to Double B Auto Sales, Inc., the West Virginia Department of Transportation, the State of New York, the National Automobile Transporter's Association, and the Federal Highway Administration.

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D. C. 20594

HIGHWAY ACCIDENT REPORT

MULTIPLE VEHICLE COLLISION AND FIRE IN A WORK ZONE ON INTERSTATE HIGHWAY 79 NEAR SUTTON, WEST VIRGINIA, JULY 26, 1990

INVESTIGATION

Accident

On Thursday, July 26, 1990, the West Virginia Department of Transportation (WVDOT) was repairing the two northbound lanes of Interstate Highway 79 (I-79) at the north end of the bridge over the Elk River near Sutton, West Virginia. A flashing electric advance warning arrow panel and traffic cones tapered the right lane closed south of the bridge. (See figure 1.) A flagger and WVDOT work vehicles, including an unoccupied dump truck, an unoccupied broom tractor, and an occupied front end loader north of the tractor, were at the work site in the closed right lane and on the shoulder near the north end of the bridge. (See figure 2.) The left lane was open to traffic. The weather was clear, and the pavement was dry.

About 5:40 p.m., a tractor-semitrailer combination (truck) operated by Double B Auto Sales, Inc., (Double B) of West Seneca, New York, transporting eight automobiles from Orange Park, Florida, to West Seneca, entered the work zone in the left lane. A truckdriver traveling in front of the Double B truck reported that he saw several advance signs advising of the work zone ahead, including a blinking arrow. When he checked his mirror before changing to the left lane, he saw the Double B vehicle about 3/4 of a mile behind him, apparently passing an automobile.

The truckdriver estimated that the speed of his own vehicle was 35 to 40 mph as he pulled into the left lane. He saw no vehicles ahead on the bridge; however, a flagger was ahead displaying a "SLOW" sign and using one hand to motion the traffic to slow down. Since he had already slowed, he presumed the flagger was motioning to someone else behind him. As he came abreast of the flagger, he saw him drop the sign and begin to frantically wave his arms. He then noticed that other workers at the site were scattering.

The WVDOT flagger reported that he saw the Double B truck approaching the bridge. The truck's initial speed, which he estimated to be about 60 mph, did not decrease as the vehicle came closer. He then signaled the truck to slow down, but the truckdriver took no apparent action to do so. The flagger reported that he did not hear a horn or any air release from the truck's brakes nor observe any evasive maneuver by the Double B truck.

A truckdriver directly behind the Double B truck estimated that its speed was 60 to 65 mph when it entered the work zone. He did not see brake lights activate on the Double B truck as it overtook the vehicles in front of it.

The Double B truckdriver reported that he approached the work site traveling in seventh gear. He could see the warning signs, the lighted arrow sign, and the "pylons" (probably traffic cones) to guide him into the left lane. The only vehicle behind him was another tractor-trailer. He switched on his left turn signal and

Figure 1.--Flashing electric warning arrow panel tapering the right lane closed south of the bridge.

turned into the left lane. As he approached the bridge in the left lane, he could see the slower moving traffic and the construction activity at the bridge. He stated that he did not see any flagger at the site.

He reported that as soon as he saw the brake lights illuminate on the vehicle ahead of him, he applied his brakes. Although he could feel braking, it was not enough to stop. He stated he tried to downshift, experienced some difficulty, and finally downshifted into sixth gear. He could not get the truck to slow down more to shift the transmission into a lower gear, and that by then, he had depressed the brake pedal almost completely. He added that his seat belt constrained him and prevented him from standing on the pedal. He then released and reapplied his brakes, but this did not prevent the collision.

The location of tire marks, gouges, and scrapes indicate that the first collision occurred about 50 feet south of the flagger's reported position. The Double B truck initially struck a utility trailer being towed by a Dodge Aspen. The trailer hitch was torn from the Aspen's rear bumper and pushed forward, and the Aspen's fuel tank was punctured. Witnesses reported that leaking fuel from the Aspen immediately burst into flames. The Aspen then struck a Plymouth Colt, which came to rest facing south pinned between the right side of the Double B trailer and the left side of the WVDOT dump truck.

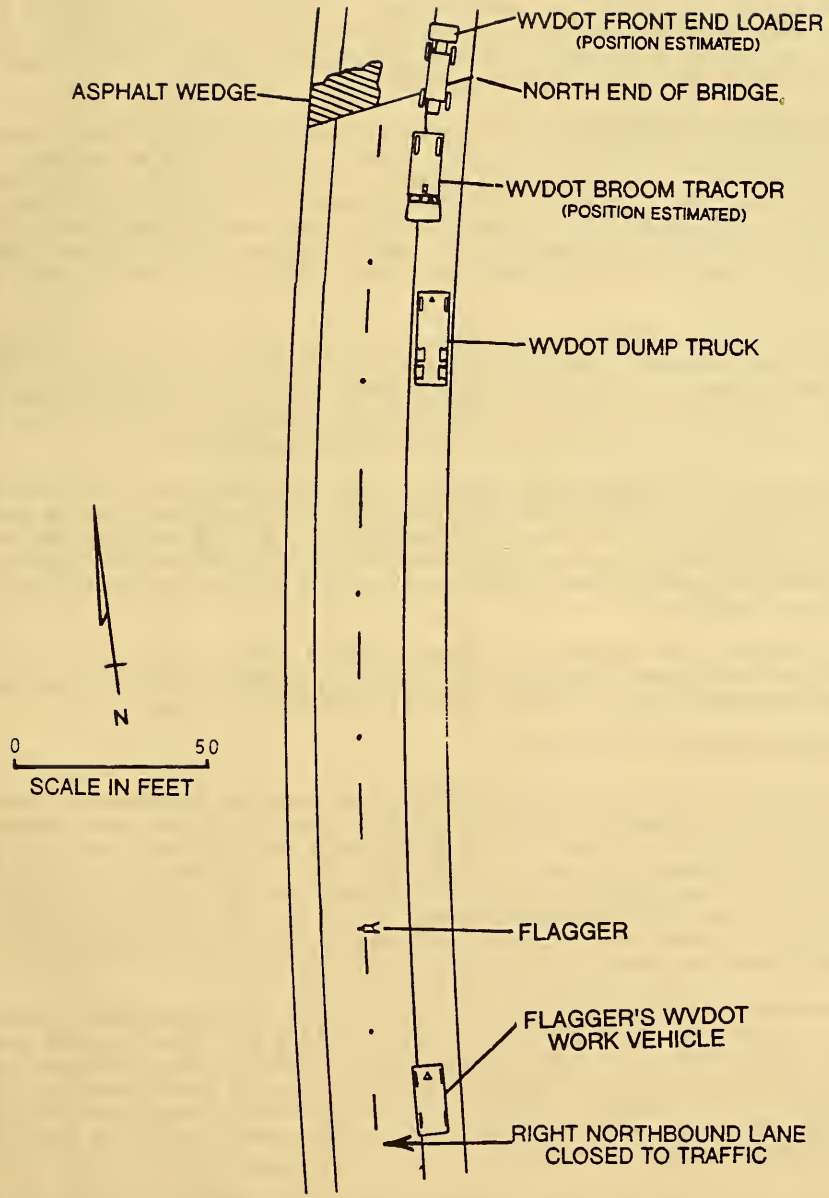

Figure 2.--Northbound lanes showing preaccident positions of flagger and WVDOT work zone vehicles on the bridge.

The Aspen came to rest with its front against the WVDOT broom tractor and its right side against the front of the Double B tractor. A Lincoln being transported on the head ramp above the Double B tractor's cab traveled forward off the ramp and came to rest on top of the Aspen's passenger compartment, crushing the Aspen's roof to the level of the dashboard and trunk lid.

The truckdriver traveling ahead of the accident vehicles reported that he heard the noise of the collision, looked in his mirror, and saw flames with an automobile emerging from them. As he continued to travel north, he felt a slight nudge at the rear of his truck. After he pulled off the roadway past the north end of the bridge, he noticed the utility trailer at rest at the edge of the road between his truck and the other accident vehicles. Examination of the rear of his truck disclosed several small scratches on the underside of the step bumper that he attributed to contact with the utility trailer's hitch.

Witnesses reported that after the accident vehicles came to rest, the fire spread within minutes from the Aspen to the Lincoln, the Double B truck, the Colt, the WVDOT dump truck, and the broom tractor. All these vehicles were either destroyed or severely damaged in the ensuing fire. (See figures 3 and 4.) The front end loader sustained minor damage in the collision and was driven clear of the fire.

Shortly after the accident, the Double B truckdriver reported to the West Virginia State Police (WVSP) that he had slowed down to about 35 mph at the time the first collision occurred. Although he remembered hitting one vehicle in the left lane, he did not remember seeing or colliding with the utility trailer. He reported that the flames began at impact. He said he then tried to steer clear of the rest of the traffic, but could not.

As a result of the accident, the three occupants of the Aspen and the five occupants of the Colt died. The Double B truckdriver sustained minor burns, and one firefighter sustained a minor laceration during extrication of the bodies.

Emergency Response

The chief of the Sutton Police Department was traveling eastbound on West Virginia State Route 4 near the point where it underpasses the accident site when he observed smoke and fire on the northbound I-79 bridge. He drove his cruiser directly up the I-79 northbound off-ramp to the accident site and witnessed the involved vehicles burning in an intense fire with 35-foot flames. WVDOT workers reported to him that an occupant was trapped in a vehicle. At 5:41 p.m., he radioed the Braxton County (West Virginia) Communication Center (911) and advised the dispatcher of "a vehicle fire with entrapment on I-79 at mile marker 62."

The dispatcher immediately notified the Sutton Fire Department (SFD). About 5:44 p.m., station one of the SFD dispatched unit 4146, a light rescue vehicle, and unit 124, a 1,500-gallon per minute (gpm) pumper. At 5:48 p.m., the SFD dispatched unit 135, a 1,000-gpm pumper. These SFD units all arrived on scene between 5:48 and 6:00 p.m. The SFD assistant chief on unit 124 was initially in charge of the fire suppression efforts and relinquished this responsibility when the chief of the SFD arrived on scene several minutes later.

Because of the thick smoke at the scene, firefighters were not initially aware of the number of vehicles or occupants involved. The SFD assistant chief reported that due to the intensity of the fire, it was apparent that the two pumpers on scene

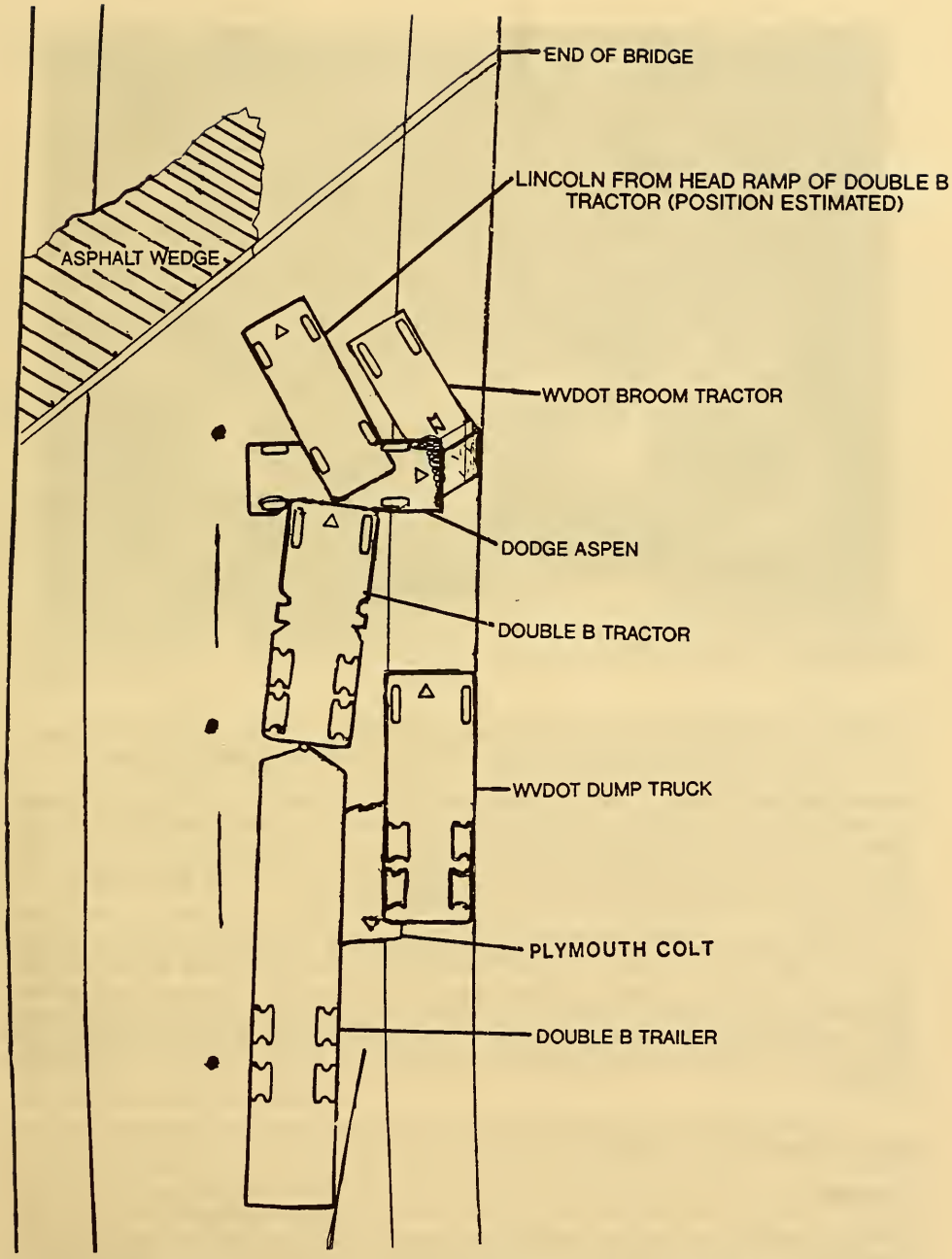

Figure 3.--Final rest positions of vehicles involved in the fire.

Figure 4.--Dodge Aspen at front of Double B tractor. The Lincoln that crushed the Aspen's roof had been removed when this photograph was taken.

would not be sufficient. At 5:50 p.m., he radioed the Braxton Communication Center requesting mutual aid. The Gassaway Fire Department's pumper No. 263 and tanker No. 274 were dispatched at 5:58 and 6:00 p.m., respectively. At 5:57 p.m., the on-scene commander requested additional mutual aid, and at 6:18 p.m., the Burnsville Fire Department tanker No. 315 was dispatched.

Units 124 and 135 initially applied a 3-percent aqueous film-forming foam agent to the fire, using two 1 1/2-inch hose lines on the north side of the accident site. These units were resupplied directly by unit 263 and later by a water drop tank located in the northbound lane of I-79. After the mass foam application blanketed and eventually extinguished the tractor fire, the firefighters advanced handlines and extinguished the vehicle fires within 45 minutes, using an estimated 10,000 gallons of water.

The SPD, a Gassaway police officer, the Braxton County Sheriff's Office, and the WVSP responded to the scene.

Damages

For all vehicles involved in this accident, the estimated damages totaled $200,000.

Injuries

	Drivers	Passengers	Others	Total
Fatal	2	6	0	8
Serious	0	0	0	0
Minor	1	0	1	2
None	0	0	0	0
Total	3	6	1	10

Truckdriver Information

General.--The Double B truckdriver was a 1982 high school graduate who was unmarried and had no dependents. He stated he drank a "lot" of carbonated soft drinks, which he purchased at rest areas or roadside stores when driving the truck. He usually stopped for a rest break every 3 hours.

He considered 8 or 9 hours to be a "normal" night's sleep. He stated that when driving on a trip, he usually got more than enough sleep. When he was on a trip he usually stayed at motels, but sometimes he slept on a padded board that fit on the seats across the cab of his truck. When he slept in the truck, he kept the doors to the cab closed and the air conditioning turned on.

After the fire, during which the interior door panels burned away, the distance in the cab from door to door measured 69 inches. The distance from the steering wheel to the driver's seatback, with all seatback padding burned away, measured 24 inches.

Medical History.--The truckdriver stated that he had no history of major illnesses, operations, or hospitalizations. He did not have a hearing problem; however, he needed glasses for reading. He stated he had not taken any medication before the accident. He possessed a medical examiner's certificate that indicated he was physically qualified to operate commercial vehicles in interstate commerce.

Employment History.--The truckdriver served as a telecommunications specialist in the U. S. Air Force from November 1982 until he was honorably discharged in April 1985. After leaving military service, he worked for a landscaping company and on odd jobs. About a year later, he received his New York Class One driver's license, which permitted him to operate tractor-semitrailer combinations.

After receiving his license, in 1986 he attended a training school for truckdrivers in Utica, New York, as a full-time student for 2 months. After graduating, his first truckdriving job was delivering liquor to stores in western New York State. He said he was fired after only a week because he had difficulty locating the stores to make the deliveries.

He reported that he subsequently worked for three auto transport firms transporting new and used autos in Canada and the United States. He received on-the-job training in operating the equipment from his first auto transport employer. This employer reported that he was a good loader and unloader, but was a poor driver who had difficulty staying awake and had appeared bored with the task of driving. This employer also reported that if the truckdriver had not resigned after 9 months' employment, he would have been fired because he had become

unreliable and tardy, had failed to report for scheduled work, and had neglected to call in daily while on road trips.

The truckdriver worked at his second auto transport job from October 1988 until May 1989. His supervisor at this auto transport company reported that the truckdriver was a good employee who was knowledgeable about his job. This supervisor stated that because the truckdriver had failed to promptly report an accident in which he overtook and struck a slower-moving vehicle in the rear, he regretfully had to fire the truckdriver.

According to the Double B truckdriver, his third job driving an auto transport lasted about 1 1/2 months and ended over a pay dispute in late 1989. After collecting unemployment compensation for 6 months, he started driving for Double B on July 1, 1990.

According to Double B records, on June 25, 1990, the Double B president gave him a 25-mile road test and found him qualified to operate a vehicle similar to the one involved in the accident. The truckdriver reported that because of his previous work experience, he received no additional training from Double B. In addition, Double B files disclosed that the truckdriver successfully completed a written test and was found to be fully qualified to operate a Double B vehicle on July 16, 1990.

Driving Violation Conviction Record.--At the time of the accident, the Double B truckdriver held a valid license, issued by the State of New York, to operate tractor-semitrailer combinations. A check with the other 50 licensing jurisdictions in the United States disclosed that at the time of the accident he held only the New York license.

The New York records indicated that between October 1988 and December 1989, the truckdriver's license had been suspended five times for failure to answer summons issued by the States of New York, New Jersey, and Pennsylvania. Each time he paid the fine, and his license was reinstated.

His license had also been assessed 15 driving points[1] between July and December 1989. As a result of these point assessments, on September 18, 1989, he was issued a letter by New York State warning that if additional driving violations occurred, his driving privilege may be suspended. After this accident, on August 19, 1990, his license was again suspended for a New York violation which had occurred on April 21, 1990. (See appendix C for additional information on the Double B truckdriver's violations, suspensions, conviction dates, and license reinstatement dates.)

As a result of this accident, the State of West Virginia charged the truckdriver with eight counts of negligent homicide. He was found innocent of these charges on December 13, 1990.

Supervision.--The truckdriver reported that when on a trip, Double B expected him to call in at least once in the morning and once in the evening. He had been instructed to drive no more than 10 hours a day. Double B did not require him to forward his duty status record (log) to the office while he was driving a trip. His last

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[1]See New York State Driver Licensing/Suspension Procedures, page 21.

duty status record on file at Double B was for July 15, 1990. He reported that the duty status records for the accident trip were destroyed in the accident fire.

Preaccident Activities.--The truckdriver left the Double B terminal in West Seneca, New York, on July 16. He picked up autos in Massachusetts and New York City and delivered them in Manassas, Virginia. He then loaded pickup trucks in Virginia destined for Orlando, Florida.

While en route to Orlando, he stopped to visit a friend in Orange Park, Florida, where he remained off duty from about 4:00 p.m. on Sunday, July 22, until about 3:00 p.m. on Monday, July 23. He delivered the trucks in Orlando about 4:45 to 5:15 p.m. He then telephoned his supervisor at Double B and discussed arrangements for his next scheduled pickups in Clearwater, St. Petersburg, and Tampa, Florida.

He arrived in Clearwater about 8:30 p.m., where it took about 30 minutes to load. The next scheduled pickup was in St. Petersburg. However, when he called to arrange the pickup, the vehicle's owner said it was too late and to come the next day.

The truckdriver then drove to an auto auction in Tampa, arriving about 11:15 p.m. He completed loading four autos about 1:15 a.m. on July 24. He reported that he then slept in his truck at the auto auction from about 1:30 to 9:20 a.m. After he awoke, he spoke with his supervisor at Double B, and then picked up the auto in St. Petersburg about 2:00 p.m. The owner of this vehicle reported the truckdriver stated that he had been up all night and had had only 2 hours sleep.

The truckdriver left St. Petersburg between 3:00 and 3:30 p.m. About 7:00 p.m., he arrived in the Jacksonville area and attempted to pick up a car, but the dealership was closed. He went off duty and stayed at his friend's apartment in Orange Park until about noon on July 25. From then until about 2:30 p.m., he was picking up the last auto of his load. He again went off duty, had lunch about 3:00 p.m., and watched two video movies at his friend's apartment in Orange Park.

He stated he left Orange Park about 10:00 p.m., drove for about 1 1/2 hours, and stopped to buy fuel near Woodbine, Georgia. He then drove north on I-95, making one 20-minute stop while he completed some paperwork. About 1:00 a.m., he arrived at a rest area, where he said he slept in the cab of his truck until 8:30 a.m.

After awaking, he said he took about 15 minutes to check the tiedown chains on the truck and started driving about 8:45 a.m. He traveled north on I-95 through Georgia and southern South Carolina; then west on I-26 to Columbia, South Carolina; on I-20 east to I-77; and then I-77 north to Route 19. Although he ate no regular meals, he estimated that he stopped two or three times for soft drinks, candy, or potato chips during the day.

While traveling on Route 19, he stopped in Summersville, West Virginia, about 4:15 p.m., where he purchased fast food and a soft drink. He left Summersville about 15 minutes later and continued to travel north on Route 19 until he reached its junction with I-79 about 4 miles south of the accident site.

According to the truckdriver's statement concerning his activities, (40 minutes for the two stops to buy fuel and to complete paperwork, 7 1/2 hours to rest in the truck cab, 15 minutes to check tiedown chains, and 1 hour for the four rest or food stops), his driving time from Orange Park, Florida, to the accident site would have been 10 1/4 hours.

Vehicle Information and Damage

Double B Truck.--The Double B truck consisted of a 1984 General Motors Corporation conventional cab, three-axle tractor operated in combination with a 1984 Delavan two-axle auto transporter semitrailer. The tractor was not equipped with a sleeper berth. The tractor had a Detroit 6V-92TA diesel engine designed to deliver 307 HP at 1,800 rpm, power-assisted steering, and a Spicer manual seven-speed transmission. After the accident, a wrecker operator reported that before towing the vehicle, he moved the transmission shift lever into neutral from seventh forward gear.

The second axle on the tractor was equipped with dual wheel assemblies with size 10R17.5 tires that had a five-rib tread design. The outside-to-outside edge static tracking width of the tires was 90 inches, and the inside-to-inside edge static tracking width was 54 inches. After the accident, the left inside tire was flat, and the other three tires had between 100 and 110 psi cold air pressure.

The third axle on the tractor was equipped with dual wheel assemblies with size 11R22.5 tires that had a four-rib tread design. The outside-to-outside edge static tracking width of the tires was 96 inches, and the inside-to-inside edge static tracking width was 52 1/2 inches. After the accident, the right outside tire on this axle was flat. The right inside tire had 63 psi cold air pressure when it was measured the day after the accident, and later lost all pressure. The left outside and inside tires had 96 and 90 psi cold air pressure, respectively.

All wheels were equipped with "S-cam" drum, air-mechanical service brakes, and the third axle on the tractor and both semitrailer axles were equipped with type 30, spring-loaded parking brake chambers. The vehicle's brake system was not equipped with automatic slack adjusters. The maintenance director for Double B reported that while the trucks were on a trip, the driver was responsible for ensuring that the brakes were properly adjusted. The truckdriver reported that the accident vehicle was assigned to him when he began driving for Double B, that after that, he was the only person who drove the truck, and that he had not adjusted the vehicle's brakes after he left on the accident trip.

Maintenance records indicated that the tractor's brakes had been overhauled in April 1990, and the president of Double B reported that the trailer's brakes were scheduled for overhaul after the accident trip. According to maintenance records all the truck's brakes were last adjusted at Double B's shop on July 11, 1990.

The fire damaged or destroyed low melting temperature steering axle brake components. Therefore, some components, such as flexible brake hoses, could not be inspected after the accident. In addition to the steering axle damage, a slight rearward displacement of the third axle's right side and damage to that axle's right brake chamber were noted.

On the Double B trailer, the left front wheel seal was found to be leaking, and the brake linings and drum were contaminated with grease. No defects were noted on the left rear trailer wheel. The lower brake lining on the right front trailer wheel was found to be contacting the drum due to a weak or stretched return spring; the cam and bearings were worn, allowing about 3/8-inch free play, and the bottom lining was cracked. The lower brake lining on the right rear wheel was worn to the

rivets, resulting in scoring and gouging of the drum. (See appendix D for additional information on the Double B vehicle's brakes.)

At each position where a vehicle could be transported, the Double B tractor and trailer was equipped with four tiedown ratchets. The ratchet shafts were equipped with a hook to secure one end of a tiedown chain to the shaft. This tiedown was accomplished by threading a link of the chain over the hook and then wrapping the chain several times around the ratchet shaft. These chain wraps were taken to eliminate direct strain on the hook and to prevent the hook from bending and releasing the chain. (See figure 5.) The other end of the tiedown chain, usually equipped with a hook, is intended to be attached to tiedown slots or brackets provided at or near each corner of the vehicle being transported to secure it to the transporter.

After the accident, tiedown chains were found hooked to the ratchet shafts at the right front, left front, and left rear of the head ramp above the tractor cab. No tiedown chain was found hooked to the ratchet shaft at the right rear of the head ramp, and the hook was straightened up and away from the shaft. (See figure 5.) The attaching bracket of the left front tiedown assembly was ripped, the car-stopper bracket was bent, and the stopper itself was missing.

A tiedown chain was found attached to the left front tiedown slot of the Lincoln that came forward off the head ramp. The tiedown bracket at the right rear of this automobile was distorted, while the tiedown slot at the right front and the tiedown bracket at the left rear were undamaged. Examination of the other automobiles being transported indicated that four were secured with four chains, but the remaining three were secured with only three chains. At all points where chains still secured vehicles to the transporter, a sufficient amount of wrap had been taken to prevent direct strain on the ratchet hooks.

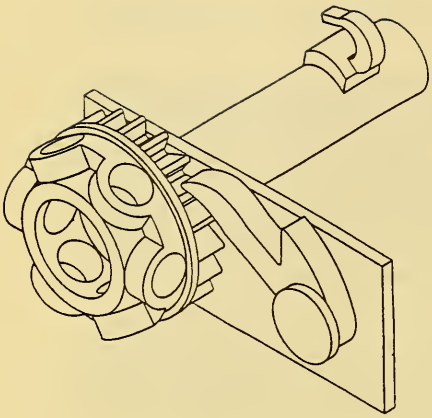
Utility Trailer.--The utility trailer towed behind the Aspen was 48.5 inches wide and had a 94-inch-long cargo bed. The tongue extended 40 inches ahead of the cargo bed. A ball coupling connected the trailer to the Aspen.

Contact damage to the rear of the trailer matched the postaccident configuration of the front bumper of the Double B tractor. The right side of the trailer displayed no contact damage.

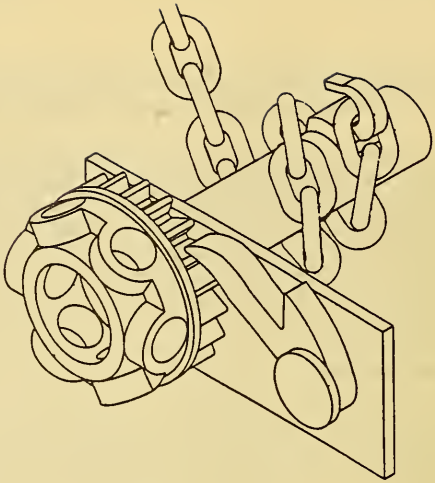
Dodge Aspen.--This 1979 passenger vehicle was a two-door sedan that had a six-cylinder gasoline engine and an automatic transmission. Postaccident examination revealed that the rear bumper was pushed inward on the left side about 18 inches. The trunk was also pushed inward adjacent to the bumper indentation. Part of the trailer hitch assembly remained bolted to the rear frame crossmember. The rear-mounted fuel tank had four external punctures on its bottom.

Contact damage on the right front consisted of marks on the fender and a rubber transfer on the bumper. The roof was crushed downward to dashboard and trunk lid level, and the vehicle sustained extensive fire damage.

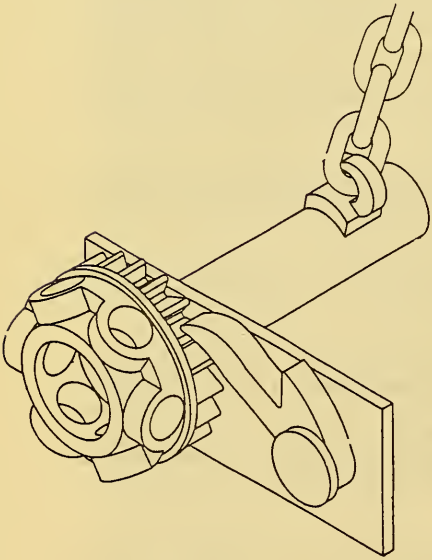
Plymouth Colt.--This 1988 passenger vehicle was a four-door sedan that had a four-cylinder gasoline engine and a four-speed manual transmission. All four sides and the roof received contact damage, and its rear was crushed to a width of 28 inches. This vehicle sustained extensive fire damage.



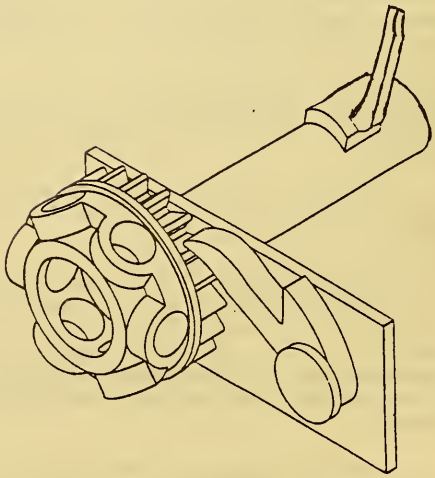
Ratchet with no chain attached.



Ratchet with properly-wrapped chain.



Ratchet with unwrapped chain.



Postaccident condition of right rear head ramp ratchet on Double B tractor.

Figure 5.

WVDOT Vehicles.--The WVDOT vehicles involved in the collision included a 1988 General Motors Corporation dump truck, a 1986 Case broom tractor, and a 1978 Ford front end loader. The left side of the dump truck showed extensive contact and fire damage. The front of the broom tractor and its right windshield pillar showed contact damage. This vehicle also sustained extensive fire damage. The only damage sustained by the front end loader was a maroon paint transfer on the rear.

Highway Information

General.--The accident occurred on I-79, a four-lane divided highway with a design speed of 70 mph, on the north end of the northbound bridge over the Elk River near milepost 61.4. From its junction with Route 19 south of the accident site, the road is a continuous downgrade; slopes range from 0.5 to 5.0 percent. The total decrease in elevation is 525 feet in about 4 miles, an average downgrade of 2.4 percent.

As the truckdriver descended the hill from Route 19, he traversed curves with radii ranging from 1,637 to 3,820 feet. About 2,900 feet before the area of initial impact, the truckdriver entered a 2,456-foot-radius curve to the right that was 2,091 feet long. About 500 feet before the area of initial impact, the curve radius decreased to 1,673 feet. This curve radius continued past the accident site.

Traffic Count.--During a week-long, 24-hour-a-day traffic count conducted in May 1990, the average daily count for the northbound traffic lanes near the accident site was 7,675 vehicles.

Road Work Description.--The 12-inch-thick concrete slabs abutting the north end of the bridge structure had settled, creating a bump at their connection to the road. Maintenance crews were preparing the slabs before putting down an asphalt overlay to eliminate the bump. During the repair operation, one lane was to be closed, and the other was to be kept open.

Work Zone Traffic Controls and Advisories.--About 2 hours after the accident, a WVDOT highway safety training officer recorded the placement of traffic signs and signals approaching the accident site. (See figure 6.) Besides the single electric advance warning arrow panel, pairs of identical work zone signs, some with amber flashing lights, were oppositely positioned on each road shoulder south of the work zone. The approximate distances between these signs and the area of initial impact are:

Feet South of Area of Impact	Sign Message or Advisory	Type of Advisory
6,300	ROAD CONSTRUCTION 1 MILE	Stationary signs with amber lights
3,250	RIGHT LANE CLOSED 1/2 MILE	Stationary signs with amber lights
2,510	WORK ZONE-SPEED LIMIT 50	Stationary signs

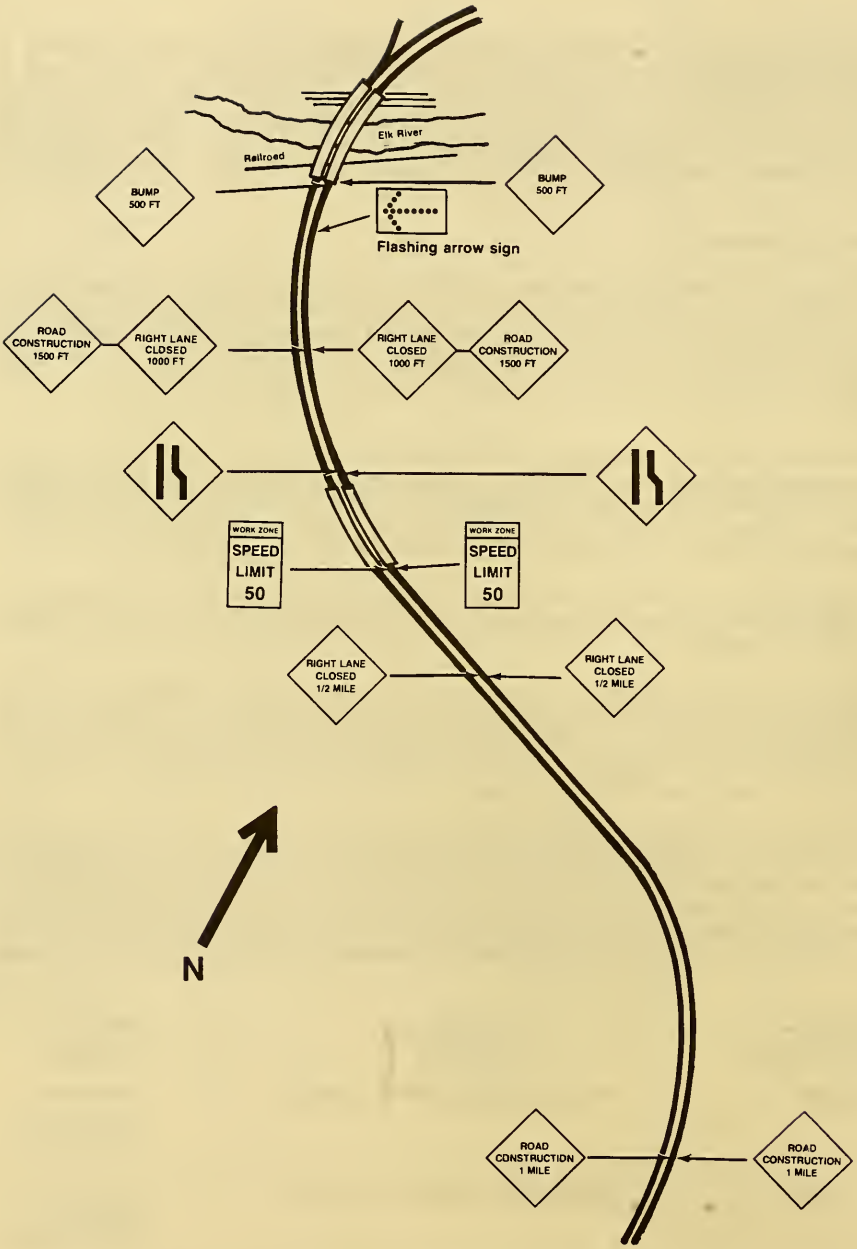


Figure 6.--Placement of road signs approaching the accident site.

1,930	Diagrammatic lane reduction signs (merge left)	Stationary signs
1,190	RIGHT LANE CLOSED 1,000 FT and ROAD CONSTRUCTION 1,500 FT	Temporary signs mounted on tripods
690	First 28-inch-high orange traffic cone beginning taper to close right lane	Traffic cones
680	Flashing electric left advance warning arrow panel on right shoulder	Electric sign
400	BUMP 500 FT	Stationary signs

The speed limit for vehicles approaching the work zone was 65 mph, and the speed limit in the work zone was 50 mph. While on scene, Safety Board investigators noted that some vehicles negotiated the work zone at speeds in excess of the posted 50 mph speed limit, while others slowed almost to a stop to cross over the temporary asphalt wedge in the left lane at the north end of the bridge.

Although the exact position of each cone was not documented, examination of photographs and video tape taken during the emergency response, as well as the positioning of the drums that were substituted for the cones after the collision, indicate that the right lane was tapered shut by cones beginning just north of the electric advance warning arrow panel over a distance of 480 to 510 feet. Cones north of the completed taper were placed either on, or within a foot to the west of, the centerline through the rest of the work zone.

In addition, the flagger reported that a WVDOT pickup truck, equipped with an over-the-cab flashing amber light bar, was parked on the right shoulder to the right of the area of initial impact.

Physical Evidence.--The first scrape marks on the pavement are attributed to contact with the utility trailer's tongue, and a burn stain began several feet north of these marks. Measurement of the distance between the first tire marks and gouges attributed to the accident and the truck's final rest position indicated that it had traveled about 240 feet from the area of initial impact.

The Double B truck was the only moving vehicle equipped with dual wheel assemblies, and dual tire marks found at the scene are attributed to the Double B truck. The dual tire marks from the right side of the truck began about 50 feet south of the flagger's reported position before the accident, and the marks from the left side began about 6 feet north of the flagger's position. These tire marks ended about 4 feet to the right of the wheels on the front axle of the Double B trailer at its final rest position and were made by tires with a four-rib tread design.

Other tire marks and burn marks on the pavement, attributed to the Aspen and the utility trailer, indicated that after initial impact, these vehicles traveled to the left up onto the median barrier and then returned toward the path of the Double B

truck. (See figure 7.) The Aspen came to rest perpendicular to the front of the Double B tractor, and the utility trailer came to rest about 100 feet north of the Aspen.

Motor Carrier Information

General.--At the time of the accident, Double B Auto Sales, Inc., maintained its place of business in West Seneca, New York. A permit issued by the Interstate Commerce Commission in October 1989 authorized Double B to perform for-hire motor carrier operations, transporting general commodities in the 48 contiguous United States under continuing contracts with commercial shippers. Double B transported new and used automobiles and light trucks under contracts with auto dealerships, auto auctions, and individuals in the eastern and midwestern United States.

Corporation managers included a president, secretary-treasurer, general manager, and operations manager. The president reported that he also served as the company's safety director. He was responsible for training driver applicants to load and unload transported vehicles and for performing road tests to determine a driver applicant's ability to operate the equipment. Double B employed 11 full-time drivers to operate its 11 tractor-semitrailer combination vehicles. In addition, Double B contracted the services of two owner/drivers, who operated their tractor-semitrailers in Double B's service.

Driver Selection and Training.--Double B required that all driver applicants be at least 23 years old. A contracted company obtained copies of driving violation conviction records for all applicants. After employment,drivers were required to immediately inform Double B of any citations for moving violations. In addition, Double B checked each employed driver's driving conviction record every 6 months. Drivers who failed to immediately report a driving citation were subject to dismissal.

Double B verified the authenticity of medical examiner's certificates presented by applicants by contacting the physician listed on the certificate. All applicants were tested for illicit drugs at the beginning of their employment, but the company had no random, for-cause, or postaccident drug testing policy. New drivers without experience were placed under the supervision of an experienced driver until they were capable of operating the equipment and loading and unloading vehicles properly.

Wages and Compensation.--The accident driver was paid 19 percent of the gross revenue for driving a "10-car" transporter. Drivers who drove an "eight-car" transporter earned 20.5 percent of the gross. The owner-operators were compensated 90 percent of the gross revenue.

Employee drivers were given $8 per day for food and other necessities, and according to Double B's drivers' manual, drivers of vehicles that were not equipped with sleeper berths were allowed to stay at motels. According to the manual, Double B stressed "economy over personal preference" in the selection of motels, and prior approval was required if a room fee was "high."

Maintenance Program.--In addition to repairing defects when they were reported by drivers, the maintenance supervisor said that Double B had a 10,000-mile vehicle inspection and maintenance schedule that included a general inspection, an oil change, lubrication, and brake adjustment if needed.

Figure 7.--Tire marks at the accident site.

Federal Oversight of Motor Carrier Operations

On December 14, 1984, the Federal Highway Administration (FHWA) advised Double B's predecessor, Body Beautiful Collision and Painting, that its interstate motor carrier operations were subject to the requirements of the Federal Motor Carrier Safety Regulations (FMCSR). On February 20, 1986, the FHWA also notified the president of Double B of this fact.

On November 3, 1987, the FHWA completed a safety review of Double B's motor carrier operations. This review disclosed that the carrier had inadequate driver qualification files for two drivers employed at that time, had no records of duty status on file for one driver, and had no system to effectively control drivers' hours of service. As a result of this review, on May 26, 1988, the FHWA notified Double B that it had received a "conditional" safety rating.[2]

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[2]A "conditional"safety rating means a motor carrier does not have adequate safety management controls in place to prevent violations of the FMCSR. An "unsatisfactory" rating indicates that this lack of control has actually resulted in FMCSR violations, such as violations of driver's license standards, the use of unqualified or fatigued drivers, or the operation of unsafe vehicles. See 49 Code of Federal Regulations (CFR) 385.

On June 10, 1990, Double B's operations manager wrote the FHWA requesting a reaudit to upgrade its safety rating. On June 26, 1990, the FHWA replied that Double B would be reaudited within 60 to 90 days. On August 13, 1990, the FHWA completed a compliance review of Double B's motor carrier operation.

This review disclosed 3 instances of using a driver without a completed certificate of written examination, 2 instances of failing to require a driver to furnish a list of motor vehicle traffic violations every 12 months, 1 instance of failing to note the review of a driver's driving record in the driver's qualification file, 2 instances of failing to maintain a driver qualification file for each driver employed, 1 instance of failing to report an accident, 3 instances of requiring or permitting a driver to drive more than 10 hours, 41 instances of requiring or permitting a driver to make false entries on a record of duty status, 60 instances of failing to require a driver to make a record of duty status, 163 instances of failing to prepare records of duty status in the form and manner prescribed, and 50 instances of failing to require a driver to prepare a driver vehicle inspection report.

At the conclusion of the review, the FHWA investigator recommended that an unsatisfactory rating be assigned because of "the pervasive pattern of duty record falsification." In addition, a report documenting the duty status falsifications would be prepared to pursue an enforcement action.

On October 22, 1990, the FHWA sent a civil forfeiture claim letter to Double B, citing the carrier for instances of requiring or permitting drivers to make false entries on records of duty status. On January 2, 1991, the FHWA and Double B executed an agreement specifying that Double B would pay a total of $5,700 for 17 counts of false records of duty status.

Toxicological and Pathological Information

The office of the West Virginia chief medical examiner performed toxicological tests on the truckdriver's blood, which was drawn within an hour after the accident. The tests included a screen for acid, basic, and neutral drugs and an immunoassay for amphetamines, acetaminophen, barbiturates, benzodiazepines, cannabinoids, cocaine, opiates, and tricyclic antidepressants. All tests were negative.

The Center for Human Toxicology in Salt Lake City, Utah, performed additional screening of the truckdriver's blood. These tests included screening for acid, basic, and neutral drugs by gas chromatography with nitrogen phosphorous detection; an immunoassay for amphetamines, cocaine, cannabinoids, opiates, and phencyclidine; and a gas chromatography with flame ionization detection to evaluate the presence of alcohol. In addition, gas chromatography mass spectrometry was used to screen for barbiturates, ephedrine, and pseudoephedrine, and an ultraviolet spectrophotometer was used to evaluate carbon monoxide levels. All test results were either negative or normal.

On July 27, 1990, the West Virginia State coroner's office performed postmortem examinations of the accident fatalities. All three occupants of the Aspen sustained 100 percent postmortem burning, with evidence of smoke in the trachea, and carbon monoxide blood levels ranging from 23 to 30 percent saturation. While no obvious trauma was evident for the two occupants of the front seat, the occupant of the rear seat had multiple blunt force head injuries.

External body examination of the two occupants of the front seat and two of the three occupants of the rear seat of the Colt showed no trauma, other than from fire and heat. The other occupant of the rear seat sustained possible prefire bilateral maxillary and right mandibular (jawbone) and right femoral (thighbone) fractures. Postmortem burning of all occupants ranged from 75 to 100 percent, and according to the autopsy report, carbon monoxide blood levels ranged from "normal" for the passengers to 16 percent for the driver.

Tests and Research

Double B In-gear Speeds.--The Double B tractor had a Rockwell R-170 single-speed drive axle with a 3.70:1 gear ratio. The drive axle wheels were equipped with size 11R22.5 tires with a measured static rolling radius of 20.5 inches. According to Double B, the normal shifting range was between 1,800 and 2,000 rpm. Using these data, the Safety Board calculated the tractor's speeds in seventh forward gear as 59 to 65 mph, respectively.

Visibility.--About 5:40 p.m. on July 28, 1990, Safety Board and WVDOT investigators drove the route the Double B truck took from the intersection of Route 19 and I-79 to the accident location. They found that since the sun was to the west and slightly behind the driver approaching the accident site, it was not a factor in the accident.

On July 29, 1990, Safety Board investigators conducted tests to determine the distance the driver could have seen to the north as he approached the bridge. The curve on the right side of the road, together with the vegetation and the rising land formation, reduced visibility ahead. To determine the distance at which the truckdriver could have seen the slower traffic ahead, a small orange construction flag was placed on a barrel near the area of initial impact. At all points 650 feet and less south of the impact area, the flag could clearly be seen.

Friction.--On July 29, 1990, Safety Board investigators and the WVSP conducted tests at the accident site with a drag sled[3] to measure the coefficient of friction between the roadway surface and a tire. The drag sled weighed 39 pounds equipped with an auto tire tread. The force necessary to drag the sled on the road was 37 pounds, for a friction coefficient of 0.95 between the tire and the road.

The available tire-pavement friction for the truck was calculated by adjusting the above coefficient for truck tires, which are made of harder material and, therefore, generally have lower friction values than automobile tires. During prior investigations, the Safety Board has determined that truck tires have about 80 percent of the frictional coefficient of automobile tires. The available truck tire friction was calculated by multiplying the friction measured using the automobile tire drag sled (0.95) times 0.80, for a truck tire frictional coefficient of 0.76.

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[3]A drag sled is a weighted device used to determine the coefficient of friction between the sled and a given surface. Dragging the sled on a surface, measuring the amount of force required to drag the sled, and then dividing that force by the weight of the sled determines the coefficient of friction. A sled equipped with a tire tread can be used to determine the tread's coefficient of friction with the surface of a road.

Weight Calculations.--The second axle on the Double B tractor was a Neway Air Ride liftable axle, which could be raised or lowered by using compressed air. The amount of the weight on this axle varied according to the amount of air pressure applied (the greater the pressure, the greater the weight). The truckdriver stated that at the time of the accident, he had the pressure level of this axle set at 47 to 48 psi.

According to Double B, the tractor's empty weight was 23,520 pounds, and the trailer's empty weight was 18,340 pounds. The eight automobiles being transported at the time of the accident had a total cargo weight of 29,200 pounds. The total gross weight of the loaded Double B vehicle is therefore estimated to have been about 71,000 pounds.

Using data for various vehicle and loading combinations provided by the trailer manufacturer, the Safety Board calculated the weight distribution on the axles. These calculations indicated that with 47 to 48 psi applied, 16 to 19 percent of the tractor's weight would be on the second axle.

A sum of moments equation was then used to calculate that the estimated gross weight of the accident tractor was about 41,250 pounds. Based on the weight distribution(s) supplied by the manufacturer, with 47 to 48 psi on the second axle the weight on the steering axle was calculated to be about 12,800 pounds, the weight on the second axle was calculated to be about 7,000 pounds, and the weight on the third axle was calculated to be about 21,450 pounds.

Two sets of calculations were made to develop a range of possible values for brake efficiency and speed. One set assumed the driver-stated application of 47 to 48 psi to the second axle, which is an extremely light application. The other assumed a 90 psi application, which according to the trailer manufacturer is in the high range of the pressure(s) usually applied.

Using loading and weight distributions provided by the manufacturer, with 90 psi applied to the second axle, calculations indicated that the load distribution would be about 11,140 pounds on the steering, about 14,640 pounds on the second, and about 15,470 pounds on the third tractor axle.

Brake Efficiency Calculations.--Since the truckdriver reported that when he stepped on the brakes the truck failed to slow and since the physical evidence appeared to indicate that only one axle with dual wheels locked during the collision sequence, the Safety Board performed a study to determine whether the truck could have experienced brake fade. The potential for brake fade was examined using the grade severity rating system (GSRS),[4] a computer model developed for the FHWA.

Factors used in the GSRS included the downgrade percentages approaching the accident site and the most likely locations approaching the accident site where braking was used. To determine the brake efficiency, which the Safety Board

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[4]The GSRS is used to assess the probability of large truck runaways on severe downgrades by determining brake temperatures for various descent speeds. It is based on a mathematical model that uses gross truck weight and physical characteristics of the downgrade to predict the temperature of the truck's brakes. Brake temperature estimates are used to determine maximum safe descent speeds for different categories of truck weight.

considered in the GSRS, the brake chamber size, tire size, push rod travel, slack adjuster length, brake lining friction coefficient, brake drum radii, and the calculated weight on each axle were included.[5]

Using a 100 psi brake application pressure and 47 and 90 psi suspension pressure applied to the second axle respectively, calculations indicated a braking efficiency loss of 35 percent with 47 psi and 30 percent at 90 psi on the second axle, or an efficiency of about 65 to 70 percent of the total maximum available truck tire friction. The maximum available truck tire friction (0.76) was then multiplied by the braking efficiency factors (0.65 to 0.70), yielding a calculated available friction coefficient of about 0.49 to 0.53 for the truck.

Since the GSRS assumes full braking efficiency and to account for the 30- to 35-percent calculated reduction in braking efficiency, the load on the truck was increased by a proportional amount to simulate a 30- to 35-percent brake efficiency loss. The GSRS calculations were then made assuming a speed of about 60 mph for the truck. The results indicated that the truck would not have experienced brake fade. The brake efficiency calculations also indicated that the tractor's second axle would have been the only axle capable of locking the wheels and, therefore, leaving skid marks on the highway surface when 47 to 48 psi was applied. When 90 psi was applied to the second axle, the third axle was the most likely to lock.

Truck Route Test Drive.--To determine possible driving times and distances a representative of the Motor Carrier Division of the Public Service Commission (PSC) of West Virginia drove the route described by the Double B truckdriver from Orange Park, Florida, to the accident site. He was unable to locate a rest area at or near where the Double B truckdriver stated he slept in his truck the night before the accident. According to the representative's calibrated odometer, the total distance from Orange Park to the accident site was 689 miles. Driving at the posted speed limit, the total driving time in the WVDOT automobile was 11 hours 9 minutes, for an average speed of 61.7 mph.

Other Information

New York State Driver Licensing/Suspension Procedures.--According to the director of the New York State Driver Improvement Program, if a driver accrues three speeding or three misdemeanor violations within 18 months, then the driver's license is automatically revoked for 6 months. If a driver receives five to seven driving violation points within 18 months, that driver is automatically flagged by the program's computer system. A warning letter is then sent to inform the driver that he is accumulating too many points and his license may be suspended or revoked. If a driver accumulates 7 to 10 points within 18 months, the computer flags the driver's record, and a more severely worded warning letter is sent. No limit exists for the number of times a license can be suspended before it is revoked, and no time elapse is required before the driver may reapply for a license. If a driver accrues 11 or more points within 18 months, the driver is not automatically suspended, but instead flagged as a "persistent violator," sent a warning letter, and reviewed by an examiner.

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[5]Heusser, Ronald B., "Heavy Truck Deceleration Rates as a Function of Brake Adjustments," Society of Automotive Engineers, No. 910126, February 1991.

During this review, an examiner may exercise one of three options for persistent violators, depending on the driving history, circumstances surrounding the violations, and the response to the warning letter(s). The first option is to take no action. The second option is to offer the choice of a voluntary temporary suspension, which may last for 20 to 60 days, or a hearing before an administrative judge. The third option is to schedule a hearing and have the administrative judge render a decision regarding the driver's status. If a hearing is scheduled, the driver retains his license until the hearing. However, the records maintained do not document decisions made by examiners or the rationale for actions taken.

New York participates in a "nonresident violator" pact to enforce restrictions on the licenses of New York drivers who have been charged with violations in other States. The State had suspended the Double B truckdriver's license until he responded to summons issued by New Jersey and Pennsylvania. New York does not assess points or fines for violations occurring in other States.

At the time of the accident, New York was not issuing the Commercial Driver License (CDL), which the Commercial Motor Vehicle Safety Act of 1986 required States to implement by April 1992. New York received authority to begin issuing CDLs on February 19, 1991.

As of the date of this report, New York will assess points for reported out-of-state violations only for driving while intoxicated or for vehicular homicide. Reports of lesser violations, such as speeding, do not result in the assessment of points.

Federal Motor Carrier Safety Regulations.--As a motor carrier operating in interstate commerce, Double B was subject to the requirements of the Federal Motor Carrier Safety Regulations (FMCSR), 49 CFR 390 to 399. Section 393.76 specifies that a sleeper berth must be a minimum of 75 inches long and 24 inches wide. Section 395.2 specifies that "on-duty" time shall include all time, other than driving time, in or upon any motor vehicle except time spent resting in a sleeper berth.[6] Section 395.3 prohibits a driver from driving more than 10 hours since his last 8 or more hours off duty and from driving after having been on duty 15 hours since the last 8 or more hours off-duty. With certain provisos, time spent resting in a sleeper berth may be substituted for the required off-duty time.

Work Zone Accidents.--From June 1, 1987, to May 31, 1990, 164,303 highway accidents were reported to the WVDOT. Of these, 2,181 accidents (1.3 percent) occurred in work zones Statewide. Accidents that occurred on West Virginia interstate highways numbered 8,409 (5.1 percent), of which 660 (30.2 percent) occurred in interstate highway work zones.

The National Highway Traffic Safety Administration (NHTSA) provided data from the Fatal Accident Reporting System (FARS). In calendar years 1987 through 1989, of the 1,970 fatal accidents in work zones, 589 (29.9 percent) occurred in work zones on interstate highways nationwide.

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[6]The CFR contains a typographical error at 49 CFR 395.2(a)(4) in that this section refers to "time spent resting in a sleeper berth as defined in paragraph (g) of this section." This section should refer to "paragraph (f) of this section."

Although large trucks accounted for 5 percent of all vehicles involved in all West Virginia accidents, 10 percent of the vehicles involved in all construction zone accidents were large trucks. In addition, 16.2 percent of the vehicles involved in interstate construction zone accidents were large trucks. A study of 1985 accident data indicated that truck combinations were overrepresented nationwide; 34 percent were involved in fatal accidents occurring in interstate highway work zones, compared to 10-percent involvement in all fatal crashes.[7]

West Virginia Work Zone Signing and Other Requirements.--The WVDOT had developed signing and spacing plans for work zones which were applicable to the zone at the accident site. In these plans, where the posted approach speed limit is 65 mph, the minimum taper length specified is 750 feet, and where the posted approach speed limit is 50 mph, the minimum taper length is 600 feet. The notes further stated:

> 1. When construction operations cause equipment to encroach the traveled way, a flagger will be required in the work zone with a FLAGGER sign placed 500 feet in advance of the flagger.
>
> 2. For day operation only, use cones on 25-foot centers and drums or Type I or II barricades at 50-foot centers. Day and night operations use drums or Type I or II barricades on 50-foot centers.
>
> 3. Longitudinal dimensions may be adjusted slightly to fit field conditions.

The WVDOT provided the Safety Board with a copy of the department's "Traffic Control for Street and Highway Construction and Maintenance Operations - July 1985," fifth printing, July 1990, excerpted as follows:

> Page 9 - 6B-11a Regulatory Speed Limit Signs The policy of the Department is that speed reduction in construction and maintenance zones through the use of regulatory speed limits shall not be used. If conditions of the roadway vary from what is considered normal, then advisory speed plates may be used.
>
> Page 11 - 6B-21 Advance Flagger Sign (W20-7A) The Advance Flagger sign is intended for use in advance of any point at which a flagger has been stationed to control traffic through a construction or maintenance project. It carries the flagger symbol. Where needed, an appropriate distance message may be displayed on a supplemental plate below the symbol sign. The sign shall be promptly removed or covered whenever the flagger is not at the flagging station.

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[7]The American Association of State of State Highway and Transportation Officials--Standing Committee on Highway Traffic Safety, "Summary Report on Work Zone Accidents," April 1987.

> Page 40 - 6F-5 Flagger Stations Flagger stations shall be far enough in advance of work site so that approaching traffic will have sufficient distance to reduce speed before entering the project. This distance is related to approach speed and physical conditions at the site; however, 500 feet is desirable.

The WVDOT informed the Safety Board that the policy on the use of regulatory speed limits was changed in 1987 to permit their limited use in work zones in which temporary concrete barriers are not used. The traffic control manual is currently being reissued; however, the reprintings of the 1985 edition do not reflect this policy change.

"Give 'Em a BRAKE" Program.--The California Department of Transportation (Caltrans) developed the "Give 'Em a BRAKE" educational program in 1982. This program initially promoted work zone safety through public awareness, donated billboard space, public service advertisements on the broadcast media, presentations to driving classes, bumper stickers, and posters. Subsequent programs involved direct mailings to print and broadcast media that included feature stories, fact sheets, press releases, brochures, and videos for driver education. Caltrans believes that the "Give 'Em a BRAKE" program has been extraordinarily successful in reducing work zone accidents.

In December 1990, Virginia conducted a survey and found that 29 States are using the "Give 'Em a BRAKE" or a similar program, and Alabama and Texas may implement the program in 1991. West Virginia has not adopted this or a similar program. (See appendix E for those States without such a program as of December 1990.)

Speed Reduction Enforcement.--For the past 5 years, West Virginia has required that contractors have a police officer present on all bridge deck overlay projects during the pouring and finishing operations. However, since the work in this accident was on the approach span rather than the bridge deck, no police officer was required at the accident site. The WVDOT reported that the police presence has been successful in reducing vehicle speeds at work sites.

Manual on Uniform Traffic Control Devices.--On October 13, 1978, the FHWA directed the States to use the Manual on Uniform Traffic Control Devices (MUTCD) for construction projects. The 1988 edition shows a construction zone similar to the accident site. The schematic of a four-lane divided highway proposes the following:

> ROAD WORK 1 MILE sign
>
> RIGHT LANE CLOSED 1/2 MILE sign
>
> A diagrammatic lane reduction transition sign (1,600 feet past the previous sign and 1,000 feet before the beginning of the taper)
>
> Trailer or truck with flasher or arrow panel in the middle of the closed lane [A December 1988 FHWA memo modified this location by placing the arrow panel at the beginning of the taper.]

Note: Taper formula L = S x W for speeds of 45 mph or more where:

L = minimum length of taper
S = numerical value of posted speed limit before work zone or 85 percentile speed
W = width of offset.

The MUTCD also specifies:

Advance Flagger Sign--This sign is intended for use in advance of any point at which a flagger has been stationed to control traffic through a construction or maintenance project.

Taper Lengths--The maximum spacing between devices in a taper should be a distance in feet which is approximately equal to the speed limit in mph.

Cone Design--The minimum height of cones used on freeways and other high speed roads is 28 inches.

Flagger Stations--Stations must be located far enough in advance of the worksite so that approaching traffic will have sufficient distance to reduce speed before entering the project. This distance is related to approach speed and physical conditions at the site; however, 200 to 300 feet is desirable.

ANALYSIS

Accident

General.--The Safety Board concludes that neither the condition of the highway nor the weather contributed to the accident. Drugs and alcohol were not a factor.

Accident Dynamics.--In determining the events that occurred during the collision sequence, the Safety Board considered the statements of witnesses to the accident, physical evidence such as marks and gouges on the pavement surface, and impact damage to the vehicles involved.

The initial collision between the Double B truck and the utility trailer broke the trailer hitch. Together with the trailer's tongue, the hitch scraped the pavement and/or the underside of the Aspen as it traveled forward and punctured the Aspen's fuel tank. The Safety Board concludes that the leaking fuel probably ignited as soon as the fuel tank was penetrated; the probable source of ignition was sparks generated when the hitch contacted the pavement surface or metal components on the underside of the Aspen.

The initial collision accelerated the Aspen and utility trailer to the speed of the Double B truck. The three vehicles traveled north together at the same speed until the right front of the Aspen, as indicated by the vehicle damage, contacted the left

rear of the Colt. This offset collision induced a clockwise rotation of the Colt away from its preaccident path.

Road evidence indicates that as the Colt rotated clockwise, the Aspen, trailing ignited gasoline and followed by the utility trailer, traveled left; these two vehicles contacted and partially rode onto the barrier on the left side of the bridge. Although the collision with the Aspen initially increased the speed of the Colt, the rotation caused the Colt's speed to decrease at a greater rate than that of the braking Double B truck, enabling the truck to overtake and strike the right rear of the Colt. (See figure 8.) This collision caused the Colt to complete a 180-degree rotation around the front and to the right side of the Double B truck. It was then crushed between the Double B truck and the left side of the WVDOT dump truck.

As the Colt was rotating around the front of the Double B tractor, the curvature of the barrier was redirecting the Aspen back onto the road. The front of the Double B tractor struck the Aspen's right side and pushed the Aspen into the WVDOT broom tractor.

The lack of contact damage on the right side of the utility trailer indicates that this part of the trailer did not come into hard contact with any other involved vehicles or fixed objects during the collision. Although no evidence indicates the point at which the utility trailer separated from the Aspen, this separation probably occurred when the Double B tractor struck the right side of the Aspen. The impact disengaged the trailer, which continued north and struck the rear of the truck that was traveling in front of the Colt.

Tire Mark Analysis.--The dual wheel tire marks attributed to the Double B truck are the type made by tires that were locked and sliding over the pavement's surface, indicating that these were made during a hard brake application. The fact that the marks ended 4 feet to the right of the final rest position of the trailer's front wheels indicates that the marks were not made by any of the trailer tires.

The second axle tires of the Double B tractor had a five-rib tread design, and the third axle tires had a four-rib design. Since the clearly discernable tire skid marks were made by tires with a four-rib design, these marks clearly were made by the tractor's third axle tires.

However, the Double B truckdriver stated that he had only 47 to 48 psi applied to the second axle, and the Safety Board's analysis using the GSRS program and brake efficiency calculations indicated that if this was the case, the second axle would have locked up. The analysis also indicated that as pressure on the second axle was increased, the third, rather than the second axle, would be more likely to lock up.

The evidence indicates that the visible tire marks at the scene were made by the third tractor axle tires, but because the outside and inside tracking widths of the third axle tires extended beyond those of the second, any tire marks made by the second axle's tires would have been overprinted by those of the third and, therefore, could not have been seen.

Speed Analysis.--The Double B truckdriver estimated that he had reduced his speed to 35 mph when the first collision occurred. Dual tire skid marks, attributed to the third axle tires of the Double B truck, began 29 feet north of the first scrape marks and indicated that the truck had traveled about 211 feet to its final rest

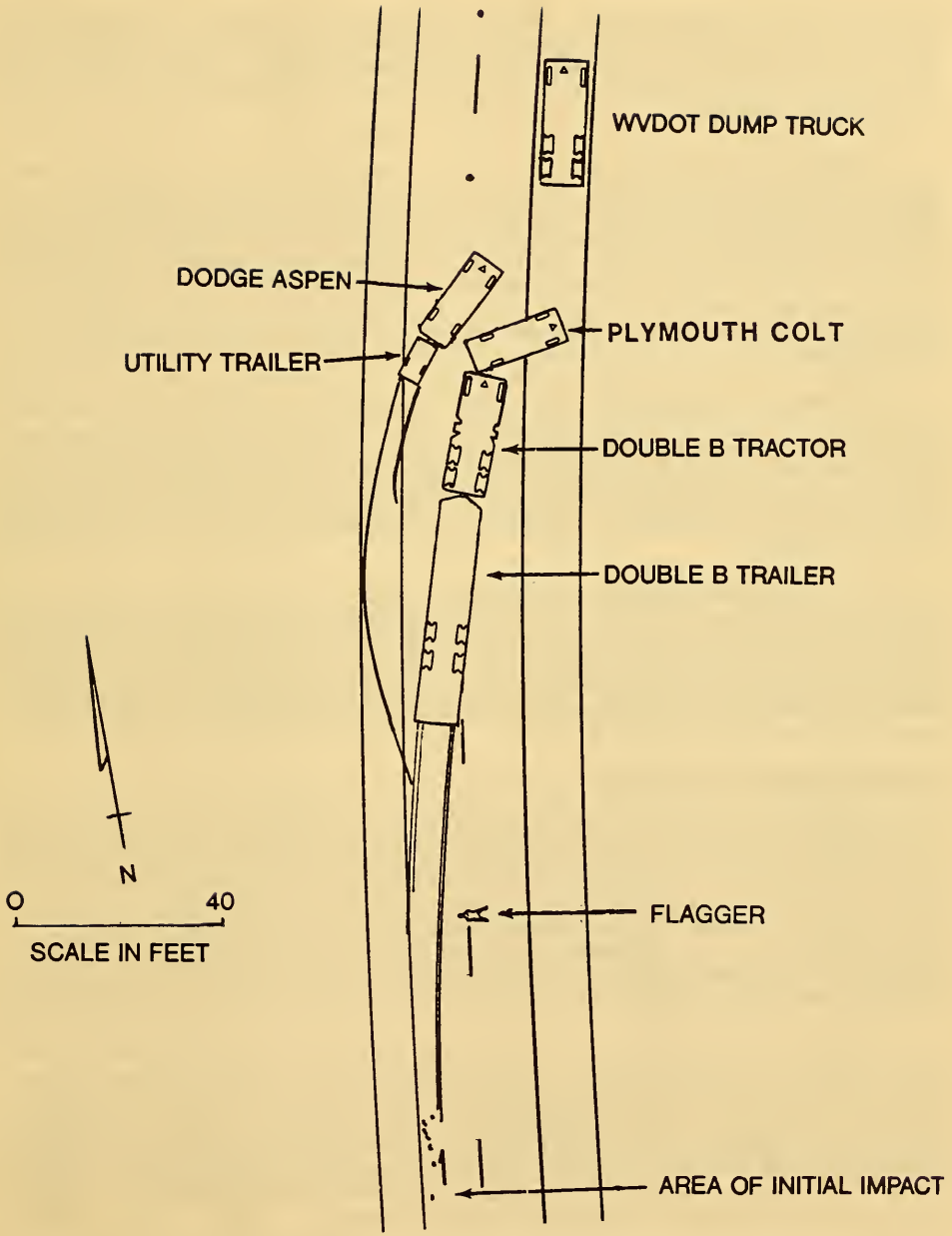

Figure 8.--Double B tractor strikes right side of Plymouth Colt.

position with its brakes applied. Based on measurements and calculations which indicated that the deceleration rate for the truck's tires was 0.49 to 0.53, to travel 211 feet and stop without colliding with any other vehicles or fixed objects, the Double B truck would have to have been traveling 55 mph at the point the skid marks became visible on the pavement surface.

However, the Double B truck did collide with other vehicles. Thus, the truck's speed at impact with the Aspen and utility trailer had to have been higher than the 55 mph minimum speed computed above. The truckdriver traveling in front of the other accident vehicles estimated that he had reduced his speed to 35 to 40 mph, and the flagger estimated that the traffic in front of the Double B vehicle had slowed to about 50 mph. Given the respective weights of the vehicles and assuming a preimpact speed of 40 to 50 mph for the Aspen and utility trailer, conservation of momentum calculations indicate that the preimpact speed of the Double B truck was 62 to 66 mph.

The Double B truckdriver stated that he had successfully downshifted from seventh to sixth gear before the collision occurred. However, the wrecker operator who towed the Double B truck from the scene reported that the transmission shift lever had to be moved into neutral from seventh forward gear before the truck could be towed. Operation of the truck at 1,800 to 2,000 rpm, which a Double B official said was the normal operating range, would result in a speed of 59 to 65 mph in seventh gear.

The Safety Board believes that the above speed estimates are consistent with the statement of the flagger, who estimated the speed of the Double B truck at 60 mph, and with that of the truckdriver, who was following the Double B truck and estimated the truck's speed at 60 to 65 mph. Therefore, the Safety Board concludes, based on calculations, physical evidence, and witness statements, that at the time of the initial collision, the Double B truck was traveling 62 to 66 mph, 12 to 16 mph over the posted work zone speed limit.

Double B Truck Brake Adequacy

Although the push rod travel on the right rear brake on the Double B tractor could not be measured after the accident, the fact that dual tire marks from this wheel began 57 feet before marks from its opposite wheel began indicates that the right rear wheel locked up before the wheel on the left rear. In addition, before the tractor could be towed, the adjustment on the right rear brake had to be released. These facts lead the Safety Board to believe that the right rear brake on the Double B tractor was properly adjusted and exerted effective braking force during the accident. (See appendix D.)

Postaccident measurements indicated that only the brakes on the rear trailer axle were above the manufacturer's recommended maximum push rod travel. Given the condition of the Double B truck's brakes at the time of the accident, an initial speed of 62 to 66 mph, and an available friction of 0.49 to 0.53, the Double B truck could have stopped at a distance of 264 to 277 feet if it had not struck anything. Calculations also indicated that optimum brake adjustment would have increased the available braking force about 6 percent. Given these parameters, the Double B truck could have stopped at a distance of 249 to 262 feet.

In either case, the 249- to 277-foot stopping distances exceed the 211 feet the Double B vehicle truck traveled to its final rest position. Since the collision with the

Aspen/utility trailer occurred first in the collision sequence and since the computed stopping distance under optimum braking conditions would still have resulted in the secondary collisions, the Safety Board believes that having optimum-adjusted brakes would not have appreciably decreased the severity of the collision.

Visibility and Time/Distance Analyses

Tests determined that unrestricted visibility in the work zone was at least 650 feet. Assuming a constant approach speed of 63 mph, the Double B truck would have traveled this distance in 7 seconds. Thus, using a minimum visibility distance of 650 feet, if the Aspen/utility trailer was stopped at the area of impact, the Double B truckdriver had a minimum of 7 seconds to observe it.

However, the witness statements indicate that the Aspen/utility trailer was moving 35 to 50 mph. If the Double B truck's approach speed was 63 mph and the Aspen/utility trailer's approach speed was 35 mph, it would have taken the Double B truck about 15 seconds to overtake the Aspen/utility trailer.

The time needed for the Double B truck to overtake the Aspen/utility trailer increases as its approach speed increases. Thus, if the Aspen/utility trailer's approach speed was 40 mph, it would have taken about 19 seconds to overtake the Aspen/utility trailer; if its approach speed was 50 mph, it would have taken about 34 seconds.

Assuming the slowest reported Aspen/utility trailer speed of 35 mph (an overtake time of 15 seconds) and given the truck's actual braking efficiency, it would have taken 2.7 seconds to slow the truck from 63 mph to 35 mph in 197 feet. Assuming an additional 0.5- to 0.75-second reaction time and a 1-second brake response time, the Safety Board concludes that the Double B truckdriver had a minimum of 10 seconds to perceive the slower-moving Aspen/utility trailer ahead and still brake in time to avoid striking it.

The truckdriver stated that he applied his brakes, could feel braking, released the brakes, and then reapplied them again before the collision. However, the flagger heard no air release and observed no evasive maneuver as the Double B truck approached, and the truckdriver traveling behind the Double B truck saw no brake lights activate as the Double B truck overtook the vehicles in front of it.

Tire marks attributable to braking by the Double B vehicle began 29 feet past the gouges and scrape marks of initial impact. Assuming a 0.5- to 0.75-second reaction time and a 1-second brake response time, the Safety Board concludes that the Double B truckdriver began to apply his brakes hard enough to lock up the third axle's wheels and leave skid marks when he was 110 to 140 feet behind the slower-moving Aspen/utility trailer.

The Safety Board's analysis indicates that the Double B truckdriver was operating his vehicle at a speed over the posted work zone speed limit. The truckdriver's failure to reduce his speed entering the work zone created a speed differential as great as 28 mph between his vehicle and the vehicles ahead in the zone. This great speed differential undoubtedly contributed to the severity of the accident.

Compliance with Federal Hours of Service Regulations

The truckdriver reported that he rested in the cab of his vehicle for 7 1/2 hours the morning of the accident. His activities, as he reported them, indicate that he drove a total of 10 1/4 hours after he left Orange Park, Florida, at 10 p.m. the previous evening. However, the Safety Board questions whether the driving time could have been as short as 10 1/4 hours.

The total distance traveled, as determined by the West Virginia PSC test run, was 689 miles. To travel this distance in 10 1/4 hours, the Double B truck would have had to average 67.2 mph over the entire trip. The Safety Board considers it unlikely that the Double B truck could have maintained this average speed under any circumstances.

In addition, because the Double B truckdriver reported that on several occasions he had pulled over to allow faster vehicles to pass in the hilly terrain, the Safety Board believes that the Double B truck could not have been driven over the route from Orange Park to the accident site at the same speed as an automobile. This indicates that it took the loaded Double B truck longer than the 11 hours 9 minutes it took the West Virginia PSC driver to travel the truck's route by automobile. The Safety Board, therefore, concludes that the Double B truckdriver drove more than the 10 1/4 hours reported. If the truckdriver made other stops as he stated, it is unlikely that he spent 7 1/2 hours sleeping or resting in the truck's cab the morning before the accident.

The FMCSR defines "on-duty" time as all time in or upon any motor vehicle, except time spent resting in a sleeper berth. The FMCSR minimum required dimensions for a sleeper berth are 75 inches long and 24 inches wide. Since the maximum interior length of the Double B truck cab was only 69 inches, the Double B truckdriver would be considered on-duty during this entire time.

The fact that on July 16, 1990, Double B executed a certificate finding the accident truckdriver fully qualified indicates that Double B was aware of the truckdriver's driving violations, convictions, and suspension record. In addition, an FHWA review of Double B's safety compliance disclosed numerous violations, indicating that although Double B could have done so, it failed to properly oversee its drivers' activities, especially in the area of compliance with Federal hours of service rules. Double B officials should institute procedures, such as inquiring when a truckdriver calls in, to determine whether he is obtaining proper rest while on overnight or longer trips. In addition, Double B should audit drivers' expense claims to determine whether truckdrivers without sleeper berths use proper facilities to obtain the required off-duty time.

Truckdriver Performance

Nutrition.--From all indications, the Double B truckdriver did not keep a regular schedule of hours for working, eating, or resting. He ate snacks that lacked nutrition and served only to stave off hunger. On the day of the accident, he ate no meals until about 1 1/2 hours before the accident.

The consequences of the truckdriver's habit of consuming soft drinks, candy, and potato chips are excessive levels, or spikes, in the blood sugar level produced for short periods. After these periods, the blood sugar level rapidly declines, often to a

level significantly lower than before ingestion of the snack food. At the time of the accident, the truckdriver may have been experiencing such a rebound in his blood sugar level because of his inadequate and unbalanced diet the day of the accident. The symptoms of this condition are inattention, irritability, headache, blurring of vision, dizziness, or irrational behavior.

Fatigue.--The truckdriver reported that he rested in the cab of his vehicle for 7 1/2 hours on the morning of the accident. However, based on the test to determine the amount of time required to drive the route, the Safety Board believes that the actual amount of time spent resting in the cab, if any time was spent, was less than 7 1/2 hours. Because of the dimensional restrictions, as well as the truck's engine noise and vibration, the cab was not a quality sleep environment.

The truckdriver's preaccident activities, including driving the truck for an extended period, an irregular work-rest schedule, poor eating habits, and inadequate rest in a poor sleep environment, leads the Safety Board to conclude that fatigue-induced inattention, exacerbated by poor diet, caused his failure to heed warning signs and to slow the truck in time to avoid the collision.

As a result of its investigation and analysis of 182 fatal-to-the-driver heavy truck accidents that occurred in eight States between October 1, 1987, and September 30, 1988, the Safety Board concluded that the most frequently-cited cause of or factor in these accidents was truckdriver fatigue.[8] This suggests that driver inattention due to fatigue may be a causative factor in an appreciable percentage of commercial vehicle accidents, and the Safety Board believes that additional efforts should be made to identify and use work zone safety devices that would be likely to prevent work zone accidents involving inattentive commercial vehicle drivers on interstate highways.

The traffic control devices in the work zone at the accident site were in substantial compliance with the MUTCD and West Virginia guidelines. The Safety Board believes that these guidelines, concerning signing and other work zone safety features, provide more than adequate advance warning for a vigilant driver, but may be inadequate for an inattentive or otherwise impaired driver. To address this problem, using the concept of the "design driver" in the establishment of work zone safety features has recently been advocated.[9] This concept assumes that some drivers traveling through the work zone may be impaired due to a medical condition or the use of alcohol or other drugs; therefore, in targeting these drivers, the use of more aggressive signing and other devices is warranted.

Based on its review of accidents involving heavy trucks that found inattention due to fatigue a significant causal factor, the Safety Board believes that the "design driver" concept should be expanded and that work zone project managers should target inattentive/fatigued drivers, as well as impaired drivers, when designing work zone safety features.

8"Fatigue, Alcohol, Other Drugs, and Medical Factors in Fatal-To-The-Driver Heavy Truck Crashes," February 5, 1990, (NTSB/SS-90/01).

9Lewis, Russell M., "Work Zone Safety; Using What We Know; Road User Characteristics in Highway Work Zones," Handout at the Transportation Research Board's Workshop on Human Factors in Transportation, January 1991.

Sustained Attention Theory.--Lapses in attention while driving are a phenomenon that most drivers have experienced. These lapses in attention have occurred, for example, when one cannot remember certain landmarks that were just seen along the route. Little is known either about the cognitive processes that occur during long duration tasks, such as driving, or about the decisionmaking requirements that are needed to make a response.

A number of theories on vigilance performance, including expectancy, signal detection, and arousal, have been proposed in research literature. All have limitations in explaining performance in tasks requiring sustained attention. While no single theory can comprehensively account for vigilance performance, research has shown that vigilance decrements are associated with losses in sensory/perceptual sensitivity, with failure to direct and maintain attention, and with shifts in the decisionmaking criteria that govern actions taken (or not taken) in response to this sensory information.[10]

Clear failures of an apparently unimpaired observer to detect, or at least to respond to, signals like those associated with work zone traffic advisories suggest a breakdown in one or more of the above-mentioned processes, but it is very difficult to determine which process has failed. Research is clearly needed to determine the characteristics of work zone traffic advisories that will attract and hold attention, provide more readily understandable displays of critical information, and counteract predictable decrements in drivers' vigilance performance. Furthermore, such research should include a wider range of driver sensory and perceptual abilities, such as the fatigued and the elderly driver. The Safety Board believes that the FHWA should conduct or sponsor such research.

Safety Board Recommendations about Human Fatigue in Transportation

On May 12, 1989, the Safety Board issued a letter to the Secretary of the Department of Transportation (DOT) containing three safety recommendations related to human fatigue as follow:

> I-89-1
>
> Expedite a coordinated research program on the effects of fatigue, sleepiness, sleep disorders, and circadian factors on transportation system safety.
>
> I-89-2
>
> Develop and disseminate educational material for transportation industry personnel and management regarding shift work; work and rest schedules; and proper regimens of health, diet, and rest.

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[10]Dember, W.N., and Warm, J.S., Psychology of Perception, 2nd edition , Holt, Rinehart and Winston, 1979; and Wickens, C.D., Engineering Psychology and Human Performance, Charles E. Merrill Publishing Company, Columbus, Ohio, 1984.

I-89-3

Review and upgrade regulations governing hours of service for all transportation modes to ensure they are consistent and that they incorporate the results of the latest research on fatigue and sleep issues.

The Secretary of Transportation responded on August 11, 1989, citing ongoing human factors research in the various modal administrations of DOT, as well as the fact that fatigue research was being considered by the DOT Research and Development Coordinating Council. Fatigue was also being considered in the formulation of the National Transportation Policy Statement, and ongoing reviews were being conducted on DOT policy regarding the dissemination of educational materials and hours-of-service regulations in the various modal administrations. The Secretary promised to keep the Safety Board apprised of progress. On October 10, 1989, the Safety Board placed Safety Recommendations I-89-1 through -3 in an "Open--Acceptable Response" status, pending further notification concerning implementation of the recommendations.

In addition, on September 12, 1990, representatives of the various DOT modal administrations briefed Safety Board staff members about DOT policy which included conducting a comprehensive program of research on human factors in transportation. The research would include the causes of transportation accidents, the effects of operator impairment, perceptual errors, and fatigue, as well as design and operating changes that can eliminate or reduce these conditions. Each of the modal administrations discussed ongoing efforts related to this issue within the respective administrations.

Within the highway mode, the Federal Highway Administration Office of Motor Carriers reported on the study designed to determine the incidence of fatigue in truckdrivers and to develop appropriate countermeasures. The study was designed to be completed in about 4 years; however, because of changes in the work plan, it is behind schedule. It is being coordinated through a technical consultation group of representatives from government, labor, industry, and the academic community, and will be fully coordinated with a companion study that the American Trucking Associations Foundation's Truck Research Institute is conducting.

The Safety Board realizes that this effort will require some time to complete. Therefore, Safety Recommendations I-89-1 through -3 will continue to be held in an "Open--Acceptable Response" status.

Survival Factors

Emergency Response.--Because the SPD chief arrived just moments after the collision, activation of the SFD was optimal. Considering the 1.5-mile distance from the SFD to the accident site, the response times of the medical units and enforcement personnel were reasonable. The fire was suppressed within 45 minutes following the arrival of emergency response personnel. The firefighting operations were safe, well organized, and adequate.

Dodge Aspen.--In addition to burns, the autopsy reports for all three occupants disclosed smoke in the trachea and carbon monoxide blood levels of 23 to 30 percent saturation. This suggests that all three occupants inhaled toxic fumes and smoke for

a brief period before they died.[11] The multiple, traumatic blunt force head injuries to the occupant in the rear seat is attributed to the downward crushing of the roof when the Lincoln from the head ramp landed on the Aspen.

Although the Double B truckdriver reported he checked the tiedowns the morning of the accident, several autos in the load were not secured using all available tiedown points. The Safety Board believes that the tiedown chain found attached to the left front of the Lincoln was from the right rear of the head ramp, where a chain was missing after the accident, indicating that the Lincoln was being transported facing rearward before the collision.

The hook provided for linking the chain to the ratchet shaft at this location was bent up and away from the shaft. Consequently, the Safety Board concludes that the Double B truckdriver used an insufficient amount of chain wrap around the right rear head ramp ratchet shaft to prevent the chain from bending the shaft hook and separating from the shaft during the collision.

In addition, the deformation of the tiedown bracket at the right rear of the Lincoln and the lack of such deformation or marking at the right front tiedown slot and left rear tiedown bracket lead the Safety Board to conclude that in addition to the inadequate tiedown at the right rear of the head ramp, the only other point securing the Lincoln to the transport was at the left front of the head ramp. Only two of four available tiedown points were used, and only one of those was used properly.

Examination of the vehicles that remained secured to the transporter indicated that although four tiedown points were provided, only three tiedowns were used on three of the vehicles. The fact that the other vehicles being transported remained secured to the transporter even though only three tiedowns were used in three cases leads the Safety Board to conclude that had the Double B truckdriver properly used all available tiedowns on the Lincoln being transported on the head ramp, the Lincoln may not have broken away from its restraints.

If the Lincoln on the head ramp had been properly restrained, the roof of the Aspen would not have been crushed, and one or more of the occupants of the Aspen may have survived by escaping or being extricated by rescuers from the windows or door on the left side of that vehicle.

Plymouth Colt.--Since this vehicle was crushed between the Double B truck and the WVDOT dump truck, its doors were either blocked or jammed closed and not accessible for occupant escape or rescue access. The autopsy reports disclosed that four of the five occupants had "normal" carbon monoxide blood levels and that the driver had a 16-percent carbon monoxide blood level, which would not be unusual for a "heavy" smoker.[12] Since carbon monoxide levels up to 30 percent in the blood are not considered incapacitating, these conditions suggest that the occupants died from heat trauma as a result of the fire.

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[11]"Analysis of Factors Impeding Passenger Escape from Aircraft Fires," Aviation, Space, and Environmental Medicine, March 1990, Wing Commander I.R. Hill, Department of Aviation and Forensic Pathology, Royal Air Force Institute of Pathology and Tropical Medicine, Aylesbury, England.

[12]Stewart, R.D., "The Effects of Carbon Monoxide on Humans," A.M. Revue Pharmacol, 15:409-423, 1975.

New York State Driver Licensing Procedures

New York does not assess driving violation points for out-of-State traffic convictions. Therefore, the Double B truckdriver received no points on his New York license as a result of his New Jersey and Pennsylvania convictions.

Had New York assessed points for these driving violations, the truckdriver's license might have been suspended for longer than the 2 days it took to settle the New Jersey violation or the 10 days it took to settle the Pennsylvania violation. The Safety Board believes that New York should institute procedures to assess driving violation points for out-of-State driving violation convictions to ensure that a driver's complete record is considered when deciding whether to suspend or revoke the driving privilege. There also should be an automotive suspension of driving privilege pending an examiner's review, and any discussion during that review, with the rationale behind it, should be documented. The New York State Driver Improvement Program should also provide a limit on the number of times a driver's license can be suspended before it is revoked and establish a period of time before the driver may reapply for licensing.

Work Zone Safety

Although the traffic control devices at the accident site were in substantial compliance with MUTCD and West Virginia guidelines, the Safety Board believes that improvements in work zone safety are possible and practical. The Safety Board is presently examining 52 other work zone accidents and may recommend additional remedial measures later. In the interim, the following safety improvements are being suggested as a result of the Safety Board's investigation of this accident.

Drum Use.--An FHWA study conducted in 1982[13] showed that cones perform as well as any device for long detection and adequate lane change distances during the day. However, during the day and at night, drums are highly visible and detectable from long distances. Drums can also promote lane changes farther up the taper and prompt motorists to reduce speeds.

The MUTCD points out that drums give the appearance of a formidable obstacle and, therefore, command the respect of drivers. One study on drivers' attitudes toward construction zones noted that "unless the driver perceives himself in danger, he will not change his driving pattern."[14] The greater size of the drum, compared to the cone, may increase perception of danger and help reduce speeds.

The WVDOT maintenance supervisor reported that placement and removal of drums at the accident site would have required about an hour more than placement and removal of cones. The Safety Board concludes that if drums had been used instead of cones, the Double B truckdriver would have had better advance visual

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[13] "Synthesis of Safety Research Related to Traffic Control and Roadway Elements," vol. 2, FHWA-TS-82-233, December 1982.

[14] "Study Concerning Driver's Attitudes Toward Construction Zones," for Deere and Company, Moline, Illinois, by Marketing Consultants, Inc., Elkhart, Indiana, April 30, 1990.

warning of the work zone and may have slowed his speed in time to reduce the severity of, or possibly avoid, the collision.

Advance Flagger Placement.--The flagger at the accident site was positioned 200 to 210 feet before the bump. The MUTCD states, "Flagger stations shall be located far enough in advance of the work site, so that approaching traffic will have sufficient distance to reduce speed before entering the project. This distance is related to approach speed and physical conditions at the site; however, 200 to 300 feet is desirable." In addition, the WVDOT manual recommends that the flagger station should be in advance of the work site so that the "approaching traffic will have sufficient distance to reduce speed before entering the project . . . 500 feet is desirable." The placement of the flagger complied with MUTCD guidelines, but not with the WVDOT manual.

The FHWA is currently revising the MUTCD pertaining to work zone flagger placement. The Safety Board believes that the MUTCD should provide for flagger placement based on actual vehicle approach speed, pavement conditions, commercial vehicle deceleration rates, and the "design driver" concept.

Both the MUTCD and the WVDOT manuals also state that the flagger should be in a position to warn workers of approaching danger, such as out-of-control vehicles. However, the greater the distance of flagger placement ahead of the actual work area, the more difficult it becomes to warn workers in the zone of an erratic vehicle's approach. The Safety Board concludes that the MUTCD and WVDOT manuals should also be revised to encourage the use of audible devices, such as warning horns, by flaggers to warn highway workers of the approach of erratic vehicles. The sounding of such a device may also serve to alert an inattentive driver.

Work Zone 10 MPH Speed Limit Reduction Increments.--The MUTCD discourages reductions of speed limits through work zones (6A-5) and notes the need to consider vehicular speed differentials (6G-2). Nonetheless, the MUTCD does point out in 6A-5 that drivers slow when they perceive a need to do so. Drivers at the accident site observed the bump or other cars bouncing through the milled section and slowed, possibly because they perceived the need to do so.

The traffic counts indicated that 5,000 to 7,000 vehicles a day traveled through the accident site work zone, and the available evidence shows that alert drivers who heeded the speed reduction signs traveled through without incident. When the Double B truckdriver did not perceive a need to slow, he continued at a high speed and created a dangerous speed differential between his truck and the other vehicles in the zone.

The Traffic Control Devices Handbook[15] states that in reducing travel speeds in work zones, when a speed reduction greater than 10 mph is unavoidable, the transition to the lower limit should be made in increments of no more than 10 mph. Since the speed limit approaching the zone was 65 mph, a 55 mph speed should have been the first speed reduction encountered by a motorist in order to be in compliance with the above guideline.

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[15]This manual was published by FHWA in 1983 to augment the MUTCD. It does not establish policies or standards. The handbook offers guidelines for implementing the standards and applications contained in the MUTCD.

Although the ideal is a work zone with no speed reduction and any speed reduction automatically creates a potentially dangerous speed differential, elimination of speed reductions in work zones is an unrealistic expectation. However, in those work zones in which the approach speed is 65 mph and the speed limit must be reduced to less than 55 mph, the Safety Board believes that an initial speed reduction of 10 mph, followed by another 10 mph reduction after an appropriate interval, may be a more effective approach than the single 15-mph reduction at the accident site.

A gradual reduction of the speed limit would have afforded the Double B truckdriver more opportunity to note the need for reducing speed and may have led him to reduce the speed differential between his and the other involved vehicles, thereby either preventing the accident or at least substantially reducing the impact severity.

Oversize Sign Use.--In 1987, AASHTO released a work zone study[16] that stated, "Special signing, lane delineation, and speed control measures may be required" for work zones. The Minnesota Department of Transportation is currently using a 7- by 10-foot speed limit sign in moving maintenance projects and reports good compliance with reduced speed limits through the zones. The Safety Board believes that oversized speed limit signs in work zones may prompt inattentive drivers, such as the Double B truckdriver, to slow their vehicles.

Lane Surface Restoration and Reopening.--Driver reactions to the bump at the north end of the bridge varied as they observed other vehicles traveling over it. The truckdriver traveling in front of the Colt reported that he slowed to about 35 mph as he approached the bump. Safety Board investigators saw other vehicles at the site slow to 30 mph or less. The slowing of vehicles to a speed below the reduced speed limit exacerbated the speed differential between the Double B truck and the other involved vehicles. The decrease in speed increased the rate of closure of the speeding truck.

The Safety Board believes that the approaching drivers' perception of pavement irregularities could be eliminated by milling one lane at a time and doing the final resurfacing of the milled area before reopening the lane. If this procedure had been followed, it may have reduced the speed differential of the vehicles, thereby giving the inattentive Double B truckdriver additional time to perceive slowing traffic ahead and properly react to it.

Other "Active" Work Zone Safety Devices.--The Safety Board believes that the FHWA and the States should develop additional devices and procedures that appeal to the various senses in order to alert an approaching driver to the presence of a work zone. Installation of "rumble strips" at decreasing intervals may cause an otherwise inattentive driver to perceive that his speed approaching a work zone is too high. Progressively decreasing the spacing of drums or barricades may also produce an awareness of excess speed.

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[16] "Summary of Work Zone Accidents," American Association of State Highway and Transportation Officials, Standing Committee on Highway Traffic Safety, April 1987.

During the investigation of this accident, WVDOT officials noted that perhaps flaggers could use citizens band (CB) radio to communicate with truckdrivers about the presence and the dangers of the work zone. The officials stated that in the past the use of CB has been successful when maintenance was being performed on truck runaway escape ramps.

Education.--The number of accidents that occur in work zones indicates the need for a nationwide educational program on the dangers of work zones.

California's "Give 'Em a BRAKE" program attempts to provide work zone safety information. Although its original emphasis was on worker safety, California has recognized the need for programs directed toward motorist safety and has developed videos and educational programs for high schools. About 28 States have adopted programs similar to California's. The Safety Board believes that West Virginia should adopt and implement a program similar to California's to educate the motoring public of the hazards of highway work zones.

Because West Virginia accident data indicate large trucks are overrepresented in work zone accidents, special emphasis should be directed toward educating commercial vehicle drivers of the hazards of highway work zones. This special emphasis area could become part of the "Give 'Em A BRAKE" program.

Enforcement.--Many States use police to control speeds at some construction sites; the enforcement efforts should be expanded further to include work zones. Studies continually reinforce the need for a police presence to obtain speed reductions. Police patrolling of the work zone may also help to identify problems before accidents occur. Police can ensure that construction vehicles obey traffic laws that foster the smooth flow of traffic through the zone, that the contractor does not interfere with moving traffic, and that all warning signs are properly used.

CONCLUSIONS

Findings

1. Neither the condition of the highway nor the weather contributed to the accident. Drugs and alcohol were not a factor.

2. Leaking fuel from the Aspen probably ignited as soon as the fuel tank was penetrated; the probable source of ignition was sparks generated when the hitch contacted the pavement surface or metal components on the underside of the Aspen.

3. At the time of the initial collision, the Double B truck was traveling 62 to 66 mph, 12 to 16 mph over the posted work zone speed limit.

4. The Double B truckdriver had a minimum of 10 seconds to perceive the slower-moving Aspen/utility trailer ahead and still brake in time to avoid striking it.

5. The Double B truckdriver began to apply his brakes hard enough to lock up the third axle's wheels and leave skid marks when he was 110 to 140 feet behind the slower-moving Aspen/utility trailer.

6. The Double B truckdriver's failure to reduce his speed when entering the work zone created a speed differential as great as 28 mph between his vehicle and the vehicles ahead in the zone. This great speed differential contributed to the severity of the accident.

7. The Double B truckdriver drove more than the 10 1/4 hours reported; therefore, it is unlikely that he spent 7 1/2 hours sleeping or resting in the truck's cab the morning before the accident.

8. Fatigue-induced inattention, exacerbated by an inadequate and unbalanced diet the day of the accident, caused the Double B truckdriver to fail to heed warning signs and to slow the truck in time to avoid the collision.

9. Had the Double B truckdriver properly used all available tiedowns on the Lincoln being transported on the head ramp, the Lincoln may not have broken away from its restraints.

10. Double B determined that the accident truckdriver was qualified under Federal requirements on July 16, 1990, and most likely was aware of the truckdriver's violation, conviction, and license suspension record when it dispatched him on the accident trip.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the inattention of the driver of the Double B Auto Sales, Inc., truck due to fatigue, exacerbated by an inadequate and unbalanced diet the day of the accident, and the inadequacy of the oversight exercised by Double B Auto Sales, Inc., to ensure that its drivers were qualified and received adequate rest. Contributing to the cause of the accident was the less than optimal work zone control devices and procedures used by the West Virginia Department of Transportation. Contributing to the severity of the accident was the operation of the Double B vehicle at a speed in excess of the posted limit, creating a speed differential between the Double B truck and the other involved vehicles, and the Double B truckdriver's failure to properly secure the automobile being transported on his vehicle's head ramp.

RECOMMENDATIONS

As a result of its investigation, the National Transportation Safety Board made the following recommendations:

--to Double B Auto Sales, Inc.:

Institute procedures to ensure that company drivers obtain required off-duty or sleeper-berth time in facilities that meet the requirements of the Federal Motor Carrier Safety Regulations. (Class II, Priority Action)(H-91-14)

--to the West Virginia Department of Transportation:

Use drums instead of traffic cones on all interstate highway work zones. (Class II, Priority Action)(H-91-15)

Place flaggers far enough in advance of work zones to accommodate longer stopping and slowing distances for heavy trucks. (Class II, Priority Action)(H-91-16)

Provide audible warning devices, such as horns, to all flaggers posted in work zones. (Class II, Priority Action)(H-91-17)

Establish policies that set speed limit reductions at 10 mph increments in work zones in which the difference between the approach speed and the speed limit in the zone is more than 10 mph. (Class II, Priority Action)(H-91-18)

Require the use of oversized signs to encourage compliance with reduced speed limits in work zones. (Class II, Priority Action)(H-91-19)

Restore the lane surface, if a project requires a lane closure, before reopening the lane to prevent large approach speed differentials. (Class II, Priority Action)(H-91-20)

Adopt and implement a program similar to California's "Give 'Em a BRAKE" program. (Class II, Priority Action)(H-91-21)

--to the State of New York:

Institute procedures to assess points for all out-of-State driving violation convictions of New York-licensed drivers. (Class II, Priority Action) (H-91-22)

Institute procedures in the Driver Improvement Program to require an automatic suspension of driving privileges for persistent violators pending review by an examiner. (Class II, Priority Action) (H-91-23)

Institute procedures in the Driver Improvement Program to document decisions made by examiners and the rationale for actions taken after a formal review of a persistent violator's driving record. (Class II, Priority Action) (H-91-24)

Institute procedures in the Driver Improvement Program to require a limit on the number of times a driver's license can be suspended before it is revoked and establish a period of time before the driver may reapply for licensing. (Class II, Priority Action) (H-91-25)

--to the National Automobile Transporter's Association:

Advise your members of the facts and circumstances of the multiple vehicle collision and fire that occurred near Sutton, West Virginia, on July 26, 1990, and request your members to remind their drivers to use all available tiedown devices

when securing vehicles to the transporter. (Class II, Priority Action)(H-91-26)

--to the Federal Highway Administration:

Conduct research to determine: a) what characteristics of work zone traffic advisories work best to counter driver inattention, and b) how to provide more readily understandable displays of critical information. Use the results of this research to design better and more meaningful work zone traffic advisories. (Class III, Longer-Term Action)(H-91-27)

Encourage the use of work zone safety devices and procedures, such as "rumble strips," that alert the various senses. (Class II, Priority Action)(H-91-28)

Encourage the use of the "design driver" concept, which assumes that some drivers are impaired or inattentive, in designing work zone safety features and signing. (Class I, Priority Action)(H-91-29)

Revise Section 6F-5 of the Manual on Uniform Traffic Control Devices to establish recommended distances for posting flaggers at work zones based on the legal speed limit approaching the zone. (Class II, Priority Action)(H-91-30)

Add a section to the Manual on Uniform Traffic Control Devices encouraging or requiring the use of audible warning devices, such as horns, by work zone flaggers to alert highway workers of the approach of an erratic vehicle. (Class I, Priority Action)(H-91-31)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ James L. Kolstad
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/s/ Susan M. Coughlin
Vice Chairman

/s/ Jim Burnett
Member

/s/ John L. Lauber
Member

/s/ Christopher A. Hart
Member

May 16, 1991

APPENDIXES

APPENDIX A

INVESTIGATION

Investigation

The news media notified the National Transportation Safety Board of this accident at 9:30 a.m. on July 27, 1990. Highway accident investigators from the Safety Board's headquarters in Washington, D C, arrived on scene at 8:30 p.m. on July 27, 1990.

Representatives of Double B Auto Sales, Inc., Delavan Industries, Inc., General Motors Corporation, the West Virginia State Police, the West Virginia Department of Transportation, and the Motor Carrier Division of the Public Service Commission of West Virginia participated in the investigation.

Depositions and Hearing

The Safety Board neither took depositions nor held public hearings on this investigation.

APPENDIX B

DOUBLE B TRUCKDRIVER INFORMATION

The Double B truckdriver was Manual Cruzado, Jr., a resident of Buffalo, New York. Mr. Cruzado, age 25 years, was single with no dependents. He had been employed by Double B Auto Sales, Inc., since July 1, 1990, and had driven on two previous trips for that employer. He had a medical certificate showing that he was physically qualified to operate commercial motor vehicles in interstate commerce. On June 25, 1990, he had been given a road test and found to be qualified to operate automobile transporters by the president of Double B Auto Sales, Inc.

APPENDIX C

DOUBLE B TRUCKDRIVER LICENSE INFORMATION

Violation, Date & State	Suspension Date	Resolution & Date
Failure to use designated lane, NJ	10/2/88	License reinstated 10/4/88.
Unknown, PA	11/5/88	License reinstated 11/15/88.
Speed 48/30, 5/30/88, NY	7/6/89	Fined $35, assessed 3 points, license reinstated 8/23/89.
Speed 52/30, 11/9/88, NY	1/26/89	Assessed 6 points, license reinstated 4/3/89.
Stop sign, 5/25/89, NY	12/2/89	Fined $25, assessed 3 points, license reinstated 12/11/89.
Stop sign, 7/1/89, NY	12/2/89	Fined $25, assessed 3 points, license reinstated 12/11/89.
Aggravated unlawful operation, unknown, PA	Unknown	Fined $200, license reinstated 12/11/89.
Operation of uninspected vehicle, 4/21/90, NY	8/19/90	Pending.

APPENDIX D

DOUBLE B TRACTOR-SEMITRAILER BRAKE DATA

	Axle No. 1	Axle No. 2	Axle No. 3	Axle No. 4	Axle No. 5
Slack adjuster length (inches)	5.5	5.0	5.0	5.0	5.0
Service brake chamber type	20	24	30	24	24
Drum size	15x4	15x7.5	16.5x7	15x7.5	15x7.5
Push rod travel measured after accident (inches): Left Side	1.5[17]	0.78	1.5	1.31	1.9
Right Side	1.62	0.65	unknown[18]	1.68	2.09
Recommended maximum push rod travel before readjustment (inches)	1.75	1.75	2.0	1.75	1.75

[17]The steering axle brake chambers were exposed to fire, and components with low melting temperatures, including brake hoses and diaphragms, were destroyed. These brake chambers were disassembled and cleaned so that all brake application parts moved freely, and each chamber was reassembled with a new diaphragm installed. Shop air at about 85 psi was then applied to determine push rod stroke lengths listed here.

[18]This brake chamber was damaged, apparently during the collision, and personnel who performed recovery operations advised that this brake could be released to permit the wheel to rotate during towing only by adjusting the brake linings away from the drum.

APPENDIX E

STATES WITHOUT A 'GIVE 'EM A BRAKE" PROGRAM AS OF DECEMBER 1990

Alaska

Alabama

Arkansas

Connecticut

Georgia

Hawaii

Idaho

Kentucky

Louisiana

Maine

Massachusetts

Nevada

New Hampshire

New York

Ohio

Rhode Island

Tennessee

Texas

Utah

Vermont

West Virginia

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